4 Concept of Operations Defined for the Regional Initiative

This chapter provides a description of the elements that compose a Concept of Operations, using examples from regional integration initiatives. It references Chapter 3 of the companion document, *Developing and Using a Concept of Operations in Transportation Management Systems Handbook*, which provides an in-depth description of each element of the Concept of Operations.

4.1 CHAPTER OVERVIEW

The purpose of this chapter is to define a Concept of Operations – using examples from regional initiatives. Its objectives are:

- To define a Concept of Operations for a regional integration project.
- To demonstrate the core elements of the Concept of Operations using transportation examples from integrated regional systems.

4.1.1 Relationship to Previous Chapter:

Chapter 3 discussed the *role* of a Concept of Operations in using the systems engineering process to implement a regional initiative. This chapter now *defines* a Concept of Operations for a regional integration project, by using regional examples. It provides more specificity in terms of the Concept of Operations itself.

4.1.2 Chapter Sections

- Concept Of Operations Defined
- Core Elements Of A Concept Of Operations: Regional Examples
- Chapter Summary
- Specific Literature Supporting This Chapter

4.2 CONCEPT OF OPERATIONS DEFINED

A Concept of Operations is a process and a document (or group of documents) that describes the users' vision of the to-be-delivered system, highlighting the current and proposed interfaces, organizational elements, and needed resources. It is: "A mechanism for documenting a system's characteristics and the user's operational needs in a manner that can be verified by the user without requiring any technical knowledge beyond that required to perform normal job functions." (*IEEE 1362-1998 Guide for Information Technology—System Definition—Concept of Operations (ConOps) Document*. New York: IEEE, 1998.) As such, is it serves as a bridge between the users' needs and the developer's technical specifications.

The Concept of Operations definition is the same for a regional integration project as it is for a local TMC development project. "No definition of 'system' states what size a system has to be. In fact, the parts of a system can themselves be systems. When we describe an ITS system, we are generally describing a 'system of systems'. Where you draw the *boundaries* of a system determines what its components are. However, the wider you draw the boundaries, the more complex the interactions of the system's parts become." (Gonzalez, Paul J. *Building Quality Intelligent Transportation Systems Through Systems Engineering*. Report No FHWA-OP-02-046. April 2002)

It is a regional integration project's *size* and *complexity of interactions* that differentiates it from a local initiative and guides the Concept of Operations development and use strategy. There are various kinds of regional initiatives for which a Concept of Operations could be developed: a regional TMC; multiple system integration; enhancement of an existing regional system. The kind and scope of the integration project will determine its level of complexity and therefore influence the Concept of Operations development process. The scope of an integration project could involve multiple TMCs, multiple states, multiple counties, a large metropolitan area, multiple corridors, multiple systems; all with a multitude of ITS component interconnects and information flows. The project might require authorization for inter-jurisdictional interoperability of communications and other equipment, multiple funding sources, and support and "buy in" from a wide variety of stakeholders.

For example, the Indiana Department of Transportation's *TrafficWise* is a statewide ITS project that integrates numerous system capabilities over a wide area, including multiple metropolitan areas: "TrafficWise is the intelligent transportation system for the State of Indiana, whose mission is to make driving easier and safer for motorists in Indiana, especially in highly traveled metropolitan areas. Operated from traffic management centers (TMC) located in Gary and Indianapolis, TrafficWise encompasses the traffic monitoring, incident detection and response, and traveler information functions of INDOT. The TrafficWise system consists of vehicle sensors and cameras to monitor traffic and detect incidents, dynamic message signs and highway advisory radio to alert motorists of current travel conditions, a real-time interactive website to provide pretrip traffic information, and communications infrastructure to link all of these systems to the traffic management centers where system data is collected and disseminated." (Indianapolis Metropolitan Planning Area Regional Intelligent Transportation System Architecture, *Inventory of Existing Documentation*, *Final Appendix A*, Prepared By Edwards and Kelcey for the Indianapolis Metropolitan Planning Organization, June 2005)

Regardless of the size and complexity of the proposed system, the major goals of a Concept of Operations remain the same and are worth repeating. The goals, as outlined in the companion document, *Developing and Using a Concept of Operations in Transportation Management Systems Handbook,* are listed below:

- Stakeholder Identification and Communication. A major goal of a Concept of Operations document is to facilitate discussion, and eventually find middle ground, among the relevant groups associated with system design, development, and operation.

- High-level System Definition. All stakeholders must understand, at a high-level, what the system is being designed to do. This will include the major entities within the system, the flows of information among those entities, the information flow to any entity external to the system, the high-level capabilities of the system, and the main daily operational occurrences for the system.

- Foundation for Lower-level System Description. The Concept of Operations is a starting point for the lower-level description of the system, beginning with a requirements document. Although the Concept of Operations is not a requirements document, a well-formed Concept of Operations will be a source of information that can be decomposed into a first cut of high-level functional requirements.

- Definition of Major User Classes and User Activities. All stakeholders are made aware of the different types of users of the system and activities those users will perform. This allows everyone who uses the document to get an idea of who is performing what task and in what order they are performing those tasks. This information then can be linked to the high-level capabilities of the system for traceability purposes (i.e. who is doing what activity, and which high-level capability is this activity supporting?)

The attainment of these goals is crucial to the guidance of the comprehensive requirements analysis needed to support design of the regional project. However, it is not *necessary* that the guidance be embodied within a single document called "Concept of Operations". It may be contained in separate documents that deal with various aspects of the system. What is important is that the relevant information is readily available and accessible to users, stakeholders, and developers and that it provide a solid foundation for supporting other systems engineering stages. While the statement above is generally true, the *ideal* practice for a regional initiative, because of the volume and complexity of the information required, is that it be contained in a single document, which can be easily referenced and shared among various interested parties so that everyone can be certain that they are on the "same page".

4.3 CORE ELEMENTS OF A CONCEPT OF OPERATIONS: REGIONAL EXAMPLES

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This section describes the basic components of a Concept of Operations. In order to illustrate the scalability of the definition, we provide a regional example for each of the core elements. The core elements are based on the ANSI/AIAA G-043-1992 standard as referenced in the companion guide, *Developing and Using the Concept of Operations in Transportation Management Systems*, and are as follows:

4.3.1 Scope

Similar to an executive summary, this subsection will outline the contents of the document, discuss the purpose for implementing the system, highlight major objectives and goals, identify the intended audience, describe the boundaries of the system, and describe an overarching vision for the system.

Kansas DOT developed a Concept of Operations for a statewide Transportation Operations and Management Center (Kansas DOT Bureau of Transportation Planning and PB Farradyne and Olsson Associates: *Transportation Operations and Management Center Concept of Operations*). Sections 1.1-1.7 of that document serve as a good example of the Scope element. It is presented in Figure 4.1 below.

Regional Example

Kansas Statewide Transportation Operations & Management Center Study

Transportation Operations and Management Center

Concept of Operations

1.1 Document Organization

The Kansas Statewide TOMC Concept of Operations document is divided up into several sections that describe and explain the reasoning behind the TOMC concept. The sections in this document are arranged as follows:

Section 1 – Introduction
The introduction section provides an executive summary of the concept of operations, the vision, goals, and objectives of the study.

Section 2 – Referenced Documents, Operations Centers, and Other Systems
Section 2 identifies key related documents to the study and other systems and operation center models that have been referenced during the study.

Section 3 – User Oriented Operational Description
Section 3 describes the users of the system and what operational functions they perform along with how they interact with other users.

Section 4 – Operational Needs
Section 4 details agency and region specific goals and objectives that will drive the requirements for the TOMC. It describes what is necessary for KDOT to complement and improve the existing transportation operations and maintenance through a TOMC.

Kansas Department of Transportation

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1.2 Purpose of the TOMC Concept of Operations

The purpose of the Concept of Operations is to provide an operational, high-level description of how a Statewide TOMC concept could impact transportation operations in Kansas. The concept identifies the functionality of a TOMC, the major users and stakeholders in a TOMC, how a TOMC can impact them, how information will be communicated between them, what the roles of other users are, and how a TOMC impacts those other users.

The very generic purpose of the Concept of Operations is to communicate an idea to multiple stakeholders in the most basic terms so that all have a clear common understanding of what they are trying to achieve. The Concept of Operations defines the business needs of the TOMC. From the Concept of Operations, functional requirements of the TOMC will be developed. The purpose of the functional requirements is to clearly define what the TOMC will do and what capabilities it must have in order to meet the business needs of the users. The Concept of Operations does not define all of the system capabilities, hardware requirements, information flows, or communication requirements. That is part of the detailed design and takes place later in the System Engineering process.

After system implementation, the Concept of Operations can be referred back to as a way of verifying that the system design met the desired functionality expressed by users and stakeholders at the beginning of the System Engineering process.

1.3 Audience for the TOMC Concept of Operations

The audience for this document includes the following stakeholders:

- Kansas Department of Transportation
- Kansas Highway Patrol

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- Kansas National Guard Adjutant General's Office
- Kansas Emergency Management
- Local Emergency Management Offices
- Federal Highway and Motor Carrier Safety Administrations
- Kansas Motor Carrier Association
- Kansas Turnpike Authority
- Kansas City Scout
- Other States
- Major Metropolitan Areas in Kansas
- Local Public Safety Agencies
- Local Public Works Agencies

1.4 TOMC Vision

Statewide ITS Vision: The overall vision for ITS in Kansas is that ITS will be an open, integrated and cost effective system that is safe and efficient to assist movement of people and goods across Kansas through the use of advanced technologies and management strategies.

Kansas Statewide TOMC Vision: With minimal impact on State of Kansas human resources and organizational structure, improve statewide operations capabilities to support interagency communication and cooperation for incident and emergency response and to support the State's mission to provide a statewide transportation system to meet the needs of Kansas.

1.5 TOMC Goals and Objectives

The purpose of a Statewide TOMC is to create an environment within Kansas that will allow for immediate and real-time transportation system operation from both the local level and a statewide level. This environment will allow for faster response to emergencies and weather related incidents and provide better quality and timelier traveler information to the users of the transportation network in Kansas.

More specifically, the Statewide TOMC will meet the following needs:

- Need 1 – Improve Incoming Communication With KDOT
- Need 2 – Improve Traveler Information Collection
- Need 3 – Improve Traveler Information Distribution
- Need 4 – Improve the Effectiveness of KDOT Operations

Kansas Department of Transportation

1.6 TOMC Functions

Stakeholders identified fifteen unique functions that should be supported or managed through the TOMC. The functions support the overall KDOT vision for ITS in general and for a TOMC. The functions also support the TOMC goals. These functions are:

- Function 1 – Operate ITS Field Devices
- Function 2 – Backup Urban TOCs
- Function 3 – Respond to Other Agencies
- Function 4 – Use External Information Service Providers
- Function 5 – Archive Transportation Data
- Function 6 – Track Permitted (OS/OW, HazMat) Trucking
- Function 7 – Share Information with Other States
- Function 8 – Manage Evacuation and Major Route Detour Traffic
- Function 9 – Collect Road Condition Information
- Function 10 – Coordinate between KDOT Districts
- Function 11 – Notify KDOT Personnel
- Function 12 – Provide Flood Warning
- Function 13 – Manage KDOT Emergency Assets
- Function 14 – Provide Travel Times
- Function 15 – Provide KDOT Resource Arrival Timeframes

1.7 TOMC Scope Boundaries

The boundaries of the TOMC are defined by the users and stakeholders who are involved in or affected by its operation. Some of these users will be an integral part of the TOMC operation while others will be external interfaces to the TOMC, which is both a receiver and transmitter of data and information with these external stakeholders.

The internal boundaries of the TOMC include the following agencies:
- Kansas Department of Transportation (KDOT)
- Kansas Highway Patrol (KHP)
- Kansas Emergency Management Agency (KEM) (including the Kansas National Guard)

The external boundaries include:
- Broadcast and Print Media
- Non-Commercial Transportation System Users
- Kansas Motor Carrier Administration
- Commercial Freight Haulers
- Adjacent States
- Federal Highway Administration (FHWA)
- Federal Motor Carrier Safety Administration (FMCSA)
- Kansas Cities and Counties
- Local 911 Centers
- Fire and Police Departments, Emergency Services
- Traveler Information Services

Kansas Department of Transportation

Figure 4.1 - Kansas DOT Transportation Operations and Management Center Concept of Operations

This figure shows Sections 1.1 - 1.7 of the Concept of Operations, which outlines the contents of the document, discusses the purpose for implementing the system, , identifies the intended audience, describes an overarching vision for the system, highlights major objectives and goals, and describes the boundaries of the system.

4.3.2 Referenced Documents

The types of resources used when developing the document will be addressed here. This can be useful to clarify the sources of information that went into the document as well as pointing the reader to additional information. The kinds of documents used include planning documents, reports, meeting minutes, concepts of operations and requirements documents (especially from the systems being integrated), and studies of operational needs. Resources might include consultation with systems experts and key personnel throughout the region, legal analysts, and elected officials

The example depicted in Figure 4.2 is from the iFlorida Draft Concept of Operations, which served as a Concept of Operations for a number of specific statewide projects related to the deployment of information infrastructure. (Florida Department of Transportation: Surface Transportation Security and Reliability Information System Model Deployment (iFlorida) *Draft Concept of Operations,* July 25, 2003)

Regional Example

Surface Transportation Security and Reliability
Information System Model Deployment

iFlorida

Draft Concept of Operations

2.0 Referenced Documents

Documents have been utilized in the development of the ConOps document include:

- iFlorida Final Work Plan, Version 1.0, PBS&J, June 2003
- Functional Requirements, iFlorida – Statewide and Central Florida Conditions System, FDOT, August 2003.
- Design and Implementation of the Central Florida Data Warehouse (CFDW) – Year 1: The TCSP Funding, UCF, October 2002.
- Design and Implementation of the Central Florida Data Warehouse (CFDW) – Year 1: The TCSP Funding, Approved Revision 6.0, UCF, May 2003.
- iFlorida Field Components Specification, PBS&J, June 2003.
- Scope of Work – Weather Forecasting by Road Segment, Meteorlogix, Version 2.3, FDOT, July 2003.
- Scope of Work – Security Command and Control, Boeing Autometric, FDOT, July 2003.
- iFlorida Conditions System Functional requirements Meeting Summary. PBS&J, July 9, 2003.
- Conditions System ITN Concept Meeting #2 Presentation, PBS&J, July 16, 2003.

In addition, information from several interviews with stakeholders and a site visit to the RTMC was utilized in the development of the ConOps. The information contained in this document has been reviewed and confirmed in a workshop environment with the iFlorida Stakeholders on July 23, 2003.

Figure 4. 2 - iFlorida Draft Concept of Operations

This figure presents Section 2 of the Draft Concept of Operations, which lists the referenced documents and other resources (interviews with transportation professionals and site visit).

4.3.3 User-Oriented Operational Description

This subsection describes the intended system operation from a user vantage point. It is also important to note how organization/system-specific goals and objectives are

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accomplished: strategies, tactics, policies, and constraints. Emphasis must be placed on who the users are and what the users do.

Figure 4.3 presents an excerpt from Next Generation 9-1-1 System Preliminary Concept of Operations. The *Next Generation 9-1-1 Initiative* is a US DOT research and development project with a multistate (nationwide) scope.

Regional Example

Next Generation 9-1-1 System

Preliminary Concept of Operations

2 User Oriented Operational Description

2.1 Operational Overview

The mission of PSAPs remains the same within an NG9-1-1 system – to receive emergency calls from the public, ascertain the nature, status and location of the emergency, and relay the call to the appropriate public safety dispatch center for response to the emergency. The call-related expectations of the PSAPs also remain the same – "calls" should be delivered to the proper PSAP within the seconds typical at many locations in the U.S. and arrive in formats that can be readily processed.

NG9-1-1 changes the core capabilities of emergency services in three areas – (1) types of calls received; (2) ability to transfer/receive calls from PSAPs outside the local region; and (3) capability to accept additional information designed to facilitate emergency services. These are expansions of current functions, not fundamentally new roles. Presently, most PSAPs can receive wireless and wire line 9-1-1 voice calls and TDD/TTY text calls and can transfer these calls to a limited number of local/regional alternate PSAPs and dispatch centers. However, there are notable differences among PSAPs on the information that can be accepted and processed with a call. For example, as of late 2005, more than 50% of counties in the United States cannot receive the location of a wireless 9-1-1 call in their PSAPs.

These changes in core capabilities will have operational implications. Some changes in operational processes and procedures will be necessary for handling the new types of

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calls and data; for working with other emergency services organizations; and purchasing, maintaining and managing new technology systems. The present local/regional government framework for PSAP and public safety communications operations will likely continue. However, the new technical capabilities (e.g. remote call acceptance and transfer) remove some of the geographic constraints on current PSAP facility location. Conversely, these new technologies require that PSAP and emergency services personnel develop new and extended working relationships with diverse and unfamiliar agencies and organizations.

Although some aspects of PSAP call taking will change, it is unclear what the impact will be on call taker[8] workload. The growth of the wireless phone market in the mid 1990s led to an increase in 9-1-1 call volume. This was primarily due to the phenomena of multiple calls for some types of emergencies. For example, it is not unusual for a PSAP to receive 50 or more calls for a single motor vehicle crash. Although NG9-1-1 will permit many more ways to call 9-1-1, this will not necessarily result in more calls per emergency in the United States beyond what would already occur due to virtual ubiquity of landline and wireless phones. In this context, NG9-1-1 may foster a replacement of some calls from one communication medium to another medium.

The current financing paradigm for the 9-1-1 system operations will likely prove inadequate in the future. Surcharges, fees and taxes on telephone equipment and services fund a significant portion of the capital and operating costs for today's 9-1-1 system. Traditional landline telephone services are being replaced by wireless and VoIP services.[9] Consequently, the corresponding revenue stream for the 9-1-1 system is expected to decline. Moreover, there is reason to believe that telephony will eventually be a "free" application available to Internet users along with email, instant messaging, and other communications applications.[10] This would further undermine the telephone-dependency for 9-1-1 funding.

While new revenue sources will be needed in the future, the good news is that costs for 9-1-1 equipment and operations should drop due to the lower costs for IP-based equipment and infrastructure. The Federal Communications Commission's (FCC) Seventh Network Reliability and Interoperability Council (NRIC VII)[11] concluded that "[w]e believe there are significant cost savings to be achieved in mortality, morbidity,

[8] "Telecommunicator" and "communications officer" are other terms for these PSAP professionals.
[9] ACA International reports that 6 percent of U.S. households have replaced landline telephone service with wireless service (http://www.acainternational.org/?cid=6488). According to FCC, household telephone subscribership has declined by 3.1% from March 2003 to March 2005 (http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-258942A2.pdf).
[10] September 2005, *The Economist* , http://www.economist.com/displaystory.cfm?story_id=4400704
[11] NRIC VII, a designated federal advisory committee, has been specifically asked to address the "future dependence of emergency communications networks on IP networks, and in particular, whether IP technologies should be used to get information to and from the PSAPs as communications networks continue to evolve."

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and operations from this new internetwork and the new services it will enable, but a significant initial investment is required."[12]

2.2 Primary System Users and Operational Processes

The quintessential operational processes for 9-1-1 will continue within the NG9-1-1 system. The general public, PSAP call takers, public safety dispatchers, and first responders will remain as the primary users of the 9-1-1 system. However, NG9-1-1 will accept a broader range of public users. The person requesting help will no longer be limited to a telephone or TTY/TDD and may use multiple communications media in a single "call." Third party service providers, such as telematics, medical alert, central alarm monitoring, N-1-1 services, and relay services, will now have direct access into the 9-1-1 system. Ultimately, "the users of the network will be any and all organizations that improve the safety of the public by being able to exchange information in emergencies."[13] This will include the police, fire, and EMS first responders but also secondary responders such as public works agencies, towing companies, and HAZMAT remediation teams.

The table 2-1 lists the key operational capabilities of the NG9-1-1 system compared to the current system for the primary users and the implications for new procedures.

Table 2-1. Key Operational Capabilities of the NG9-1-1 System

User	Current Capabilities	Key Changes	New Process and Procedural Issues
General Public	• Call local 9-1-1 directly via telephone, cell phone, TTY/TDD, possibly VoIP • Call PSAP indirectly (not using the 9-1-1 system) via 3rd party emergency or relay service via a broader range of communication options • Deliver location and callback number, with various restrictions	• More viable options for communicating directly with PSAPs • More capabilities for delivering data beyond location and callback. • Direct support of 3rd party originated 9-1-1 calls • More options for receiving up-to-date information, warnings and/or instructions on large-scale events. • Greater ability to get through to someone who can help in disaster or other mass calling situations	• Understanding/knowing if device/service is E9-1-1 capable. • Understanding/knowing qualitative differences in E9-1-1 capabilities (e.g., E9-1-1 via residential wire line provides more reliable location than cell phone from inside building) • Universal access code/symbol for emergency access from all (or most) devices. "9-1-1" is not the telephone access code used by most countries. • New ways to obtain, represent and convey location • New ways to route a call given location • New ways to obtain information related to the location, call, caller • Security-related factors (certification; authentication), threats (e.g., denial of service attacks), and potentially differing impacts on citizen access depending on access service. • Privacy issues.
PSAP Call takers	• Receive local E9-1-1 calls from telephone, cell phone, TDD/TTY, possibly VoIP users • Voice, TTY/TDD text and location data are the only accessible information sources from callers. • Transfer 9-1-1 call to/from a limited number of local PSAPs • Handoff a 9-1-1 call to a limited number of local public safety dispatch entities	• Increased number of viable methods for receiving E9-1-1 calls (= more accessible to the public) • More data available in addition to location. • Capability for transferring calls to/from any emergency service entity, independent of geographic location.	• Receiving, switching, logging, etc. voice, video and text media streams • Displaying, acting on and forwarding new kinds of data • Training, policies and procedural issues for "long distance" 9-1-1 activities. • Confidentiality issues. • Network security issues
3rd Party Service Providers	• Receive voice, text, data, images and video via full range of communication options • Relay emergency service request to PSAP via 10-digit administrative lines, not as "native" 9-1-1 calls.	• Expect s more appropriate remote transfer capabilities as PSAP-PSAP (e.g. call delivery through the emergency services internetwork). • Ability to originate 9-1-1 calls on behalf of client, with routing based on location of client • Ability to supply additional data related to location, call, client • Ability to have automatic conference with CSR, Call taker and client	• Certification, authentication, and other requirements for access to Public Safety Network(s).
Public Safety Dispatchers	• Dispatchers can receive call, ALI/ANI data, and supplemental text provided by PSAP call taker. • Depending on CAD/RMS capabilities, can access and integrate additional data relevant to particular emergency. • Key information relayed to responders verbally. Depending on mobile capabilities, some data can be transferred to responders.	• Additional data or links to relevant data resources will be included with all "calls."	• Information triage issues – overload issue. • More devices to create "abandoned" calls. • Training, policies and procedural issues.
First Responders	• Typically receive voice instructions from dispatcher via radio • Increasing, MDTs in vehicles can receive and access additional data beyond the 9-1-1 call information	• Additional data or links to relevant data resources may be included via MDTs and other wireless devices. • Improved "mobility" = improved response times (acknowledgement to transport) • Improved access to up-to-date information on events. • Multimedia stream access (e.g. surveillance video)	• Information triage issues – overload issue. • Confidentiality issues. • Network security restrictions • Training, policies and procedural issues • Privacy issues (transport/3rd party access)
Secondary Responders	• Typically, government and private secondary responders (e.g., public works, transportation, towing and recovery) are notified by public safety dispatchers via telephone • Electronic notification and sharing of some incident data is operational in a few locations	• Additional data or links to relevant data resources may be included in electronic notifications. • More integration into public safety incident networks • Improved "mobility" = improved response times (acknowledgement to transport) • Improved access to up-to-date information on events.	• Information triage issues – overload issue. • Confidentiality issues ("need to know" issues) • Network security issues • Training, policies and procedural issues • Privacy issues (transport/3rd party access

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Figure 4. 3 - Next Generation 9-1-1 System Preliminary Concept of Operations

This figure is an excerpt from Section 2 User Oriented Operational Description of the Preliminary Concept of Operations, which describes an overview of operational changes proposed for the new system and discusses the implications for the various users.

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4.3.4 Operational Needs

This subsection addresses the question of what is required by the region that the current system or set of services does not provide. This implies a description of the process for identifying these requirements and for establishing their relationship to the current operational environment.

The Concept of Operations and Action Plan, prepared by Western Transportation Institute College of Engineering, Montana State University-Bozeman for Modoc County Transportation Commission (California), addresses Operational Needs for a rural, multi-county project that will include the implementation of trip-planning technology and the creation of a Mobility Management Center (MMC) "that would provide a 'one stop shop' for transportation information within the given region". This is shown in Figure 4.4.

Please note that a scenario style was employed here to illustrate a shortcoming of the current system. Later we will discuss the use of scenarios as a Core Element that describes the operation of the proposed system under expected conditions.

Regional Example

Western Transportation Institute
College of Engineering
Montana State University – Bozeman

Rural California Transportation
Coordination and Technology Plan

Concept of Operations and Action Plan

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2. CURRENT SITUATION AND NEED FOR CHANGE

This section focuses on the current transportation situation in Inyo, Lassen, Modoc, Mono and Plumas counties, and the reasons to modify how the services are currently being provided.

2.1. Current Situation

As identified in the Tri-County Non-Emergency Medical Transportation (NEMT) study [1], the region identified in Figure 1 faces barriers that are common in rural areas. Great distances, low population densities, and limited funding lead to transit systems with limited coverage areas, shorter service hours and fewer days of operation. To receive specialized health care, people in these counties have to travel to Chico, Redding, Sacramento, or Truckee, California; Klamath Falls, Oregon; or Reno, Nevada.

To travel to these destinations, people with limited access to a car may use the public transportation systems, a Medi-Cal van, senior transportation programs, volunteer drivers, agency vehicles, gas vouchers, veteran services vans, for hire cars, private intercity shuttles, or taxis [1]. Depending upon an individual's origin and destination, transfers between one or more providers may be necessary to complete a particular trip.

Currently, there is no single source of information for the various transportation options within the five-county region. To get a general idea of how the current system works, suppose David, a college-educated, computer-literate potential rider, needed to use web-based information to schedule a trip from Alturas in Modoc County to Lone Pine in Inyo County. To determine how to make this trip, he could start with the Sage Stage web site [2]. The web site gives information about the current schedules and a map showing the routes and stops. The information from the website is shown in Figure 2, Figure 3, and Figure 4.

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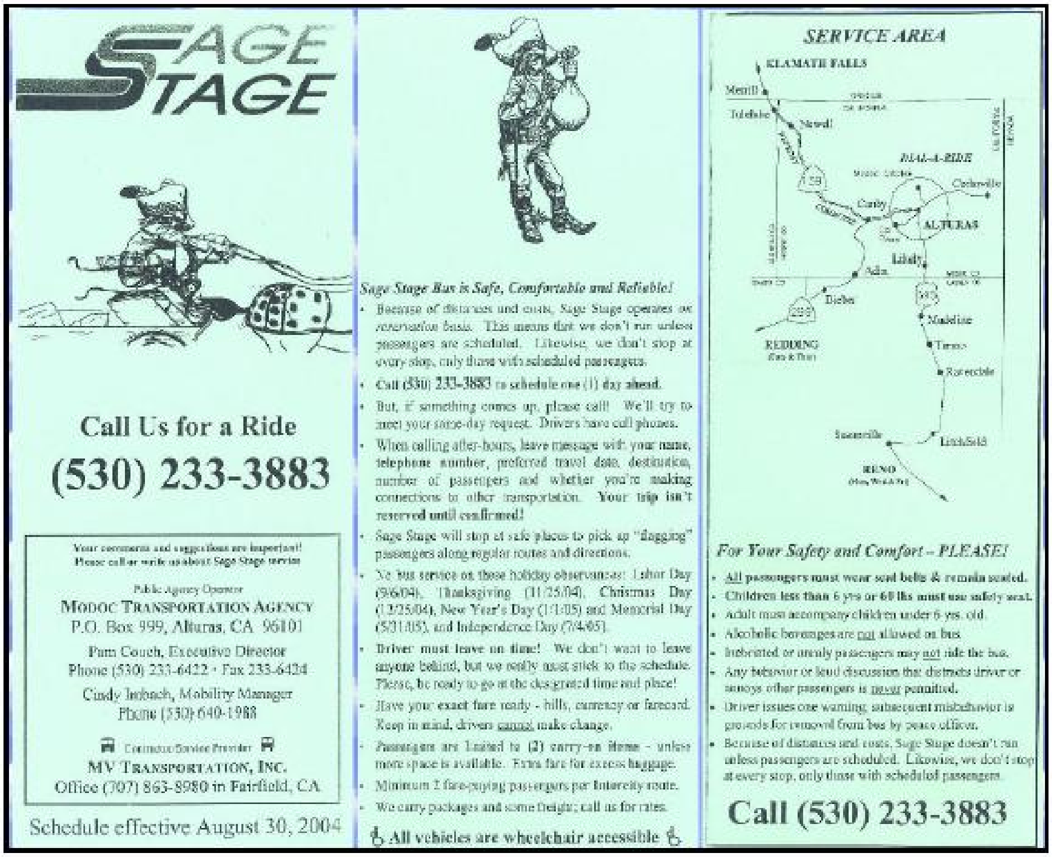
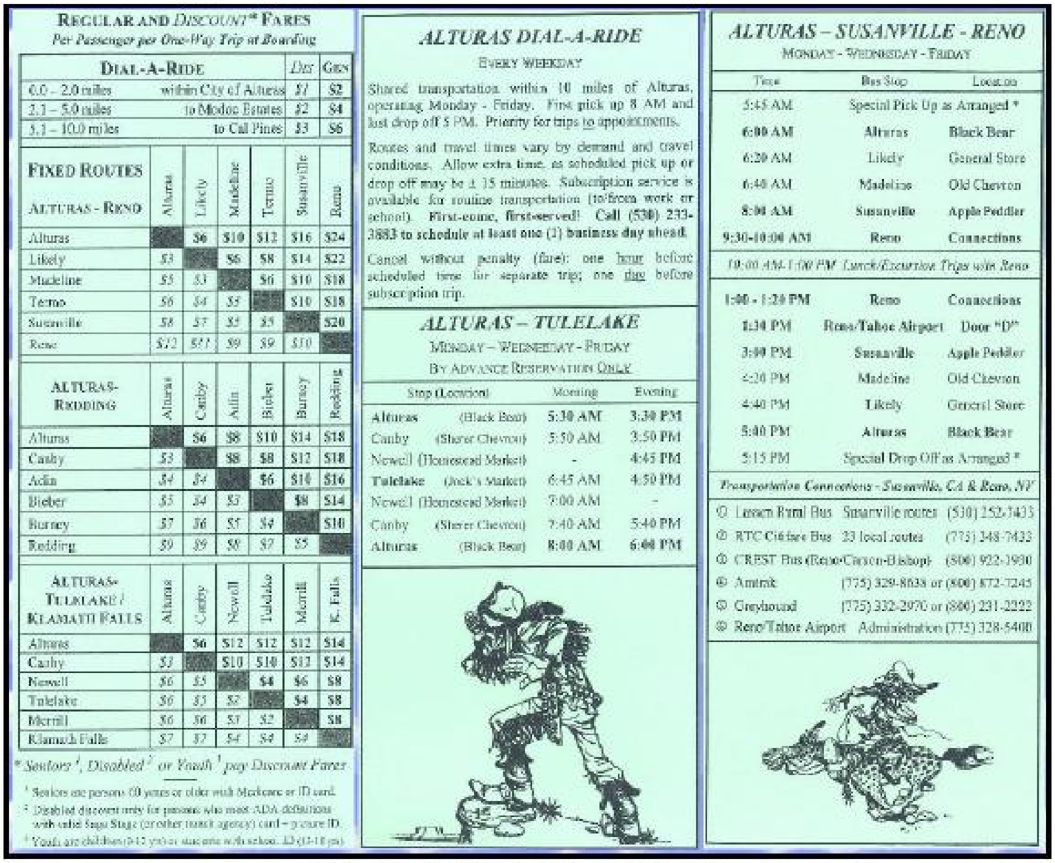


Figure 2 - Sage Stage Website Page 1

As David browses the web page, he notices the map that shows that service is available to Reno on Mondays, Wednesdays and Fridays. As David scrolls down to the second page on the website, Figure 3, he sees the schedule for the service from Alturas to Reno.



REGULAR AND *DISCOUNT FARES**
Per Passenger per One-Way Trip at Boarding

DIAL-A-RIDE		*DIS*	GEN
0.0 – 2.0 miles	within City of Alturas	*$1*	$2
2.1 – 5.0 miles	to Modoc Estates	*$2*	$4
5.1 – 10.0 miles	to Cal Pines	*$3*	$6

FIXED ROUTES ALTURAS - RENO	Alturas	Likely	Madeline	Termo	Susanville	Reno
Alturas		$6	$10	$12	$16	$24
Likely	*$3*		$6	$8	$14	$22
Madeline	*$5*	*$3*		$6	$10	$18
Termo	*$6*	*$4*	*$3*		$10	$18
Susanville	*$8*	*$7*	*$5*	*$5*		$20
Reno	*$12*	*$11*	*$9*	*$9*	*$10*	

ALTURAS-REDDING	Alturas	Canby	Adin	Bieber	Burney	Redding
Alturas		$6	$8	$10	$14	$18
Canby	*$3*		$8	$8	$12	$18
Adin	*$4*	*$4*		$6	$10	$16
Bieber	*$5*	*$4*	*$3*		$8	$14
Burney	*$7*	*$6*	*$5*	*$4*		$10
Redding	*$9*	*$9*	*$8*	*$7*	*$5*	

ALTURAS-TULELAKE / KLAMATH FALLS	Alturas	Canby	Newell	Tulelake	Merrill	K. Falls
Alturas		$6	$12	$12	$12	$14
Canby	*$3*		$10	$10	$12	$14
Newell	*$6*	*$5*		$4	$6	$8
Tulelake	*$6*	*$5*	*$2*		$4	$8
Merrill	*$6*	*$6*	*$3*	*$2*		$8
Klamath Falls	*$7*	*$7*	*$4*	*$4*	*$4*	

** Seniors [1], Disabled [2] or Youth [3] pay Discount Fares*

[1] Seniors are persons 60 years or older with Medicare or ID card.
[2] Disabled discount only for persons who meet ADA definitions with valid Sage Stage (or other transit agency) card – picture ID.
[3] Youth are children (3-12 yrs) or students with school ID (13-18 yrs).

ALTURAS DIAL-A-RIDE
EVERY WEEKDAY

Shared transportation within 10 miles of Alturas, operating Monday - Friday. First pick up 8 AM and last drop off 5 PM. Priority for trips to appointments.

Routes and travel times vary by demand and travel conditions. Allow extra time, as scheduled pick up or drop off may be ± 15 minutes. Subscription service is available for routine transportation (to/from work or school). First-come, first-served! Call (530) 233-3883 **to schedule at least one (1) business day ahead.**

Cancel without penalty (fare): one hour before scheduled time for separate trip; one day before subscription trip.

ALTURAS – TULELAKE
MONDAY – WEDNESDAY – FRIDAY
BY ADVANCE RESERVATION ONLY

Stop (Location)		Morning	Evening
Alturas	(Black Bear)	**5:30 AM**	**3:30 PM**
Canby	(Sharer Chevron)	5:50 AM	3:50 PM
Newell	(Homestead Market)	-	4:45 PM
Tulelake	(Jack's Market)	6:45 AM	4:50 PM
Newell	(Homestead Market)	7:00 AM	-
Canby	(Sharer Chevron)	7:40 AM	5:40 PM
Alturas	(Black Bear)	**8:00 AM**	**6:00 PM**

ALTURAS – SUSANVILLE - RENO
MONDAY - WEDNESDAY - FRIDAY

Time	Bus Stop	Location
5:45 AM	Special Pick Up as Arranged *	
6:00 AM	**Alturas**	**Black Bear**
6:20 AM	Likely	General Store
6:40 AM	Madeline	Old Chevron
8:00 AM	**Susanville**	**Apple Peddler**
9:30-10:00 AM	**Reno**	**Connections**
10:00 AM-1:00 PM Lunch/Excursion Trips with Reno		
1:00 - 1:20 PM	**Reno**	**Connections**
1:30 PM	**Reno/Tahoe Airport**	**Door "D"**
3:00 PM	**Susanville**	**Apple Peddler**
4:20 PM	Madeline	Old Chevron
4:40 PM	Likely	General Store
5:00 PM	**Alturas**	**Black Bear**
5:15 PM	Special Drop Off as Arranged *	

Transportation Connections - Susanville, CA & Reno, NV

① Lassen Rural Bus Susanville routes (530) 252-7433
② RTC Citifare Bus 23 local routes (775) 348-7433
③ CREST Bus (Reno-Carson-Bishop) (800) 922-1930
④ Amtrak (775) 329-8638 or (800) 872-7245
⑤ Greyhound (775) 322-2970 or (800) 231-2222
⑥ Reno/Tahoe Airport Administration (775) 328-6400

Figure 3 - Sage Stage Website Page 2

David sees the schedule for service between Alturas and Reno, notes the times of service, and the cost ($24). David sees the "Transportation Connections" that show the CREST Bus service to Bishop, but is still unsure of how to get from Reno to Lone Pine. David could call the 800 number to get further information, or look on the Internet for further information.

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ALTURAS - REDDING

TUESDAY - THURSDAY

Time	Bus Stop	Location
6:45 AM	Special Pick Up as Arranged *	
7:00 AM	**Alturas**	**Black Bear**
7:20 AM	Canby	Clinic/Chevron
7:40 AM	Adin	Adin Supply
7:55 AM	Bieber	Kathy's Corner
8:20 AM	Fall River Mills	H&C Cookhouse
8:40 AM	Burney	McDonalds
10:00-10:30 AM	**Redding**	**Connections**
10:30 AM-1:30 PM Lunch/Excursion Trips w/in Redding		
1:30-1:50 PM	**Redding**	**As Needed**
2:00 PM	**Transit Center**	**California Street**
3:10 PM	Burney	McDonalds
3:30 PM	Fall River Mills	H&C Cookhouse
3:55 PM	Bieber	Kathy's Corner
4:10 PM	Adin	Adin Supply
4:40 PM	Canby	Clinic/Chevron
5:00 PM	**Alturas**	**Black Bear**
5:15 PM	Special Drop Off as Arranged *	

Transportation Connections in Redding, CA

① RABA (Redding Area Bus Authority) (530) 241-2877
② Amtrak feeder bus (800) 872-7245 or amtrak.com
③ Greyhound (530) 241-2070 or (800) 231-2222
④ ABC Cab Co (530) 233-5909
⑤ ABC Taxi (530) 244-5909
⑥ Redding Yellow Cab (530) 222-1234

SPECIAL PICK UP / DROP OFF FARES

Before / After Intercity Trip Alturas DAR zone & fares

EXCURSION FARES

Shuttle service <5 miles during layover in terminus city

$6 / regular passenger $3 / discount passenger

ALTURAS – KLAMATH FALLS

WEDNESDAY

Time	Bus Stop	Location
7:45 AM	Special Pick Up as Arranged *	
8:00 AM	**Alturas**	**Black Bear**
8:20 AM	Canby	Clinic/Chevron
9:10 AM	Newell	Market
9:20 AM	Tulelake	Jock's Market
9:50-10:00 AM	**Klamath Falls**	**Connections**
10:00 AM-1:30 PM Lunch/Excursion Trips w/in K. Falls		
1:30-1:50 PM	**Klamath Falls**	**As Needed**
2:00 PM	**Transit Center**	**Near K-Mart**
2:30 PM	Tulelake	Jock's Market
2:40 PM	Newell	Market
3:25 PM	Canby	Clinic/Chevron
3:45 PM	**Alturas**	**Black Bear**
4:00 PM	Special Drop Off as Arranged *	

Transportation Connections in Klamath Falls, OR

① Basin Transit local bus routes (541) 883-2877
② Shuttle to Medford or Lakeview, OR (541) 883-2609
③ Amtrak (541) 884-2822 or (800) 872-7245
④ Greyhound (541) 882-4616 or (800) 231-2222
⑤ Klamath Falls Airport Admin. (541) 883-5372

CANBY CONNECTIONS

WEDNESDAY

Time		Bus Stop / Location
8:00 AM	(Via K Falls Bus)	Alturas
8:20 AM		Canby (Clinic)
10:40 AM		Alturas (Black Bear)
11:00 AM	(Round Trip 1)	Canby / Clinic
11:20 AM		Alturas (Black Bear)
12:40 PM		Alturas (Black Bear)
1:00 PM	(Round Trip 2)	Canby / Clinic
1:20 PM		Alturas (Black Bear)
3:25 PM	(Via K Falls Bus)	Canby / Clinic
3:45 PM		Alturas

Figure 4: Sage State Website Page 3

Since David's destination is in Inyo County, David next searches to find out about bus services in Inyo County. David finds the Inyo Mono website [3] shown in Figure 5.

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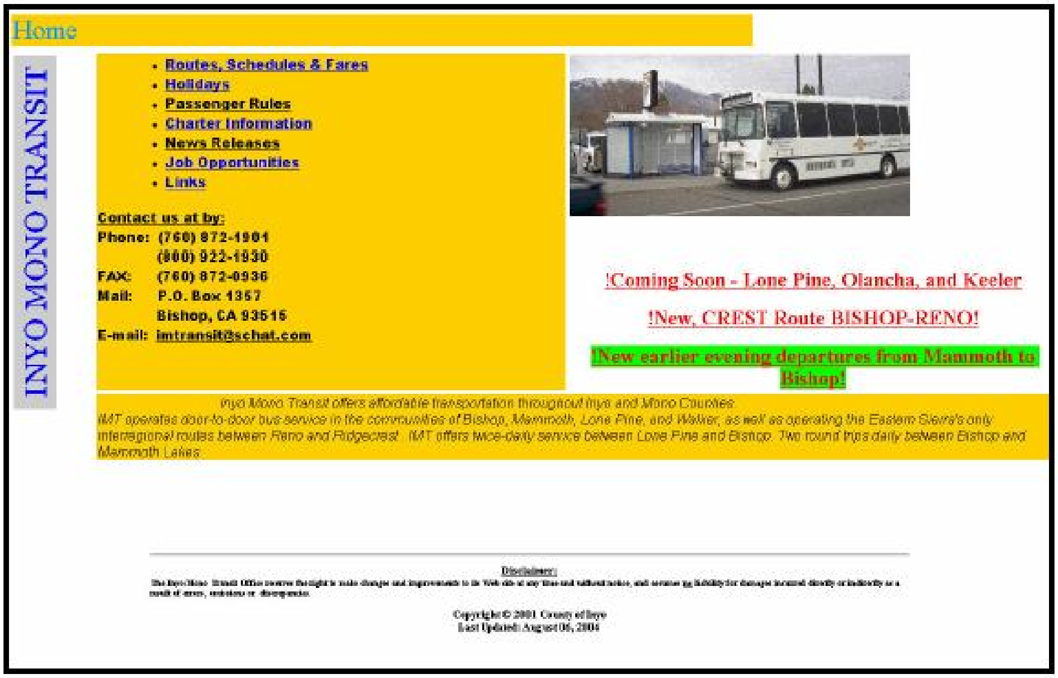

Figure 5: Inyo Mono Transit Homepage

David sees the link highlighting the new route from Reno to Bishop and clicks on that link. The link takes him to the schedule and fare information, shown in Figure 6 and Figure 7.

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INYO MONO TRANSIT

FARES

Traveling NORTH
Between Bishop and Reno

From:	Adults	Discount
Bishop	$ 28.00	$ 23.00
Tom's Place	$ 25.00	$ 20.50
Crowley Lake	$ 24.50	$ 20.00
Mammoth	$ 23.00	$ 18.50
June Lake	$ 21.00	$ 16.50
Lee Vining	$ 20.00	$ 15.50
Bridgeport	$ 17.00	$ 13.00
Walker	$ 13.00	$ 10.00
Coleville	$ 12.50	$ 9.50
Topaz	$ 11.50	$ 9.00
Carson	$ 8.00	$ 6.00

Traveling SOUTH
Between Mammoth and Ridgecrest

From:	Adults	Discount
Mammoth	$ 21.00	$ 17.50
Crowley	$ 18.50	$ 15.50
Tom's Place	$ 18.00	$ 15.00
Bishop	$ 15.50	$ 13.00
Big Pine	$ 14.00	$ 11.50
Aberdeen	$ 13.00	$ 10.50
Independence	$ 11.00	$ 9.00
Lone Pine	$ 9.50	$ 7.50
Olancha	$ 7.00	$ 5.50
Coso Junction	$ 5.00	$ 4.00

Additional fare information available from the driver or by calling Monday through Friday
8:00 a.m. to 5:00 p.m. Reservations are strongly recommended.
To confirm your ride please call (760) 872-1901 the prior business day.

Prices and times are subject to change - Please call to Confirm.

Figure 6: Reno-Bishop Fares

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Traveling NORTH
Between Bishop and Reno
Tuesdays-Thursday-Friday

Location	A.M. Departure Times	P.M. Return Times
Bishop 201 S. Warren terminal	7:00 am	5:30 pm
Tom's Place ** Storefront	7:30 am	5:00 pm
Crowley Lake ** Crowley Storefront	7:35 am	4:55 pm
Mammoth McDonalds	7:50 am	4:40 pm
June Lake** Fire House	8:15 am	4:15 pm
Lee Vining Caltrans Yard	8:25 am	4:05 pm
Mono City**	8:35 am	3:55 pm
Bridgeport Bridgeport General Store	8:55 am	3:35 pm
Walker Walker Sporting Goods	9:35 am	2:55 pm
Coleville ** Across from Post Office	9:45 am	2:45 pm
Topaz ** Trailer Park Entry	10:00 am	2:30 pm
Gardnerville **	10:35 am	2:15 pm
Carson City - Nugget Robinson St. & Hwy 395	10:45 am	1:45 pm
Reno Airport	11:45 am	11:45 am

** By request stops only

Traveling SOUTH
Between Mammoth and Ridgecrest
Monday-Wednesday-Friday

Location	A.M. Departure Times	P.M. Return Times
Mammoth Mc Donald's	8:05 am	4:50 pm
Crowley Crowley lake Store	8:20 am	4:35 pm
Tom's Place	8:25 am	4:30 pm
Bishop 201 S. Warren terminal	9:15 am	3:50 pm
Big Pine Texaco Bench	9:30 am	3:35 pm
Aberdeen** Storefront	9:45 am	3:20 pm
Independence Mair's Market	10:00 am	3:05 pm
Lone Pine Statham Hall	10:25 am	2:50 pm
Olancha** Ranch house restaurant	11:45 am	2:30 pm
Coso Junction** Rest stop	11:05 am	2:10 pm
Pearsonville** Texaco Parking Lot	11:20 am	1:55 pm
Ridgecrest City Hall 100 W. California Ave.	11:45 pm	1:30 pm

** By request stops only

Figure 7: Reno-Bishop Schedule

David reviews the information and sees that he would have a layover in Reno from about 10:00 am until 11:45 am. David sees that he would depart Reno at 11:45 am and arrive in Bishop at 5:30 pm.

David then goes back to the Inyo Mono Transit homepage to figure out how to get from Bishop to Lone Pine. After David sees the link for "Route Maps, Schedules and Fares" Figure 8, he clicks on the "Lone Pine to Bishop" link and sees the specific route and fare information (Figure 9).

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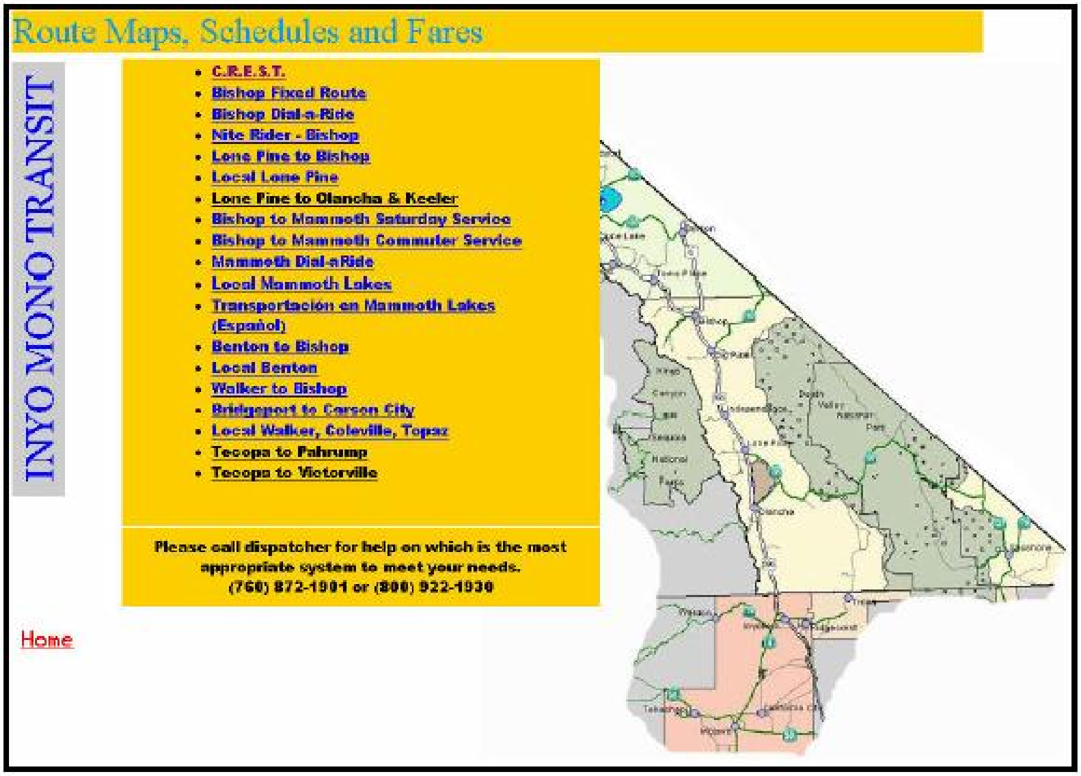

Figure 8: Inyo Mono Transit Route Map and Schedules

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Lone Pine to Bishop

INYO MONO TRANSIT

INYO MONO TRANSIT
LONE PINE TO BISHOP

Monday thru Friday
Two Round Trips Daily

	MORNINGS		AFTERNOON	
	Arrive	**Depart**	**Arrive**	**Depart**
Lone Pine - Statham Hall		6:30 am		12:30 pm
Independence - Austin's Mkt.	6:45	6:45	12:47	12:47
Aberdeen - Store**	7:00	7:00	1:03	1:03
Big Pine - Carrol's Mkt	7:20	7:20	1:22	1:22
Bishop - Kmart	7:40		1:45	
Bishop - Kmart		12:00 (noon)		5:30 pm
Big Pine - Texaco	12:15	12:15	5:45	5:45
Aberdeen - Store**	12:30	12:30	6:05	6:05
Independence - Mairs Mkt.	12:45	12:45	6:20	6:20
Lone Pine - Statham Hall	1:00		6:40	

** Must call day prior to request bus.

FIRST SATURDAY OF EVERY MONTH

Departs		**Departs**	
Lone Pine – Statham Hall	8:30 am	Bishop - Kmart	3:00 pm
ndependence – Austin's Mkt.	8:45	Big Pine - Texaco	3:15
Big Pine – Carroll's Mkt	9:15	Independence - Mair Mkt.	3:45
Bishop – Kmart	9:30	Lone Pine - Statham Hall	4:00

Figure 9: Bishop to Lone Pine Schedule

David sees that he can leave Bishop at 5:30 pm and arrive in Lone Pine at 6:40 pm. David's trip itinerary is shown in Table 1:

Table 1: Alturas-Lone Pine Trip Itinerary

Action	Time	Service	Cost
Depart Alturas	6:00 am		
Arrive Reno	10:00 am	Sage Stage	$ 24.00
Depart Reno	11:45 am		
Arrive Bishop	5:30 pm	CREST	$ 28.00
Depart Bishop	5:30 pm		
Arrive Lone Pine	6:40 pm	Inyo Mono Transit	$ 4.00
Totals	12 hours 40 min.	3 providers	$ 56.00

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For David, who has proficient computer skills and a decent understanding of bus schedules, it could take at least 30 minutes to put together this itinerary using the current system. A person who is unfamiliar with the Internet would likely take longer and may not be able to identify the trip at all. Of course, another option would be to call the various providers directly. When calling the providers, the individual would hope that the providers know of the possible transfers, and the other providers' services, so they could suggest possible routings to complete the trip.

The above scenario shows how difficult it currently is for an individual to plan a trip from one town to another. In addition, it is difficult for a single transportation operator to have detailed information about all the various transportation options within the region. This scenario shows how important it is to have a one stop shop, or a single source for transportation options within the region.

The scenario also shows how current information is critical to the concept of trip planning. As schedules change, new brochures must be produced, and webpages must be updated. Dispatchers must be educated of changes, and the new information must be shared with current and potential riders.

With the current system, a change with one transportation provider may have an impact on clients of other transportation providers. The current system makes it harder to maintain current information, and share any changes to schedules, routes, etc., with the public or other providers. With the current system, individual transit providers are responsible for maintaining their web sites, ensuring that all information about the transit system is current.

Further, individuals at the transit systems are typically available to answer questions during normal office hours (8:00AM – 5:00PM). Therefore, if someone wanted to plan a trip during the evening or weekends, they may have limited access to the information they need to plan the trip.

All of the issues concerning trip planning and transportation information noted in this section highlight the need for changes to the current system, which are discussed in detail in the next section.

2.2. Need for Change

The transit systems in Inyo, Modoc, Mono and Plumas counties have a website. Lassen County is currently developing a web site. The web sites' objective is to provide information and schedules about the individual service. They are somewhat limited in scope in that they usually provide information only about their own service. Information regarding possible connections with other transit services is typically not provided. These individual web sites may not have the most current information, and may not be constantly operational (on-line), and hence their effectiveness as individual information dissemination centers is limited. Potential travelers can, however, also get information about transit in their county through paper schedules or by calling the transit provider. There are limitations to these approaches, which have already been discussed.

Currently, if a customer needs to travel in the eastern Sierra corridor using public transportation, the customer is responsible for planning the trip. If the service is available through a single provider, the trip planning is fairly simple. The customer accesses the web site or paper schedule; reserves a seat with the transit agency, if required, then makes the trip.

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However, as the earlier scenario showed, if the desired trip requires changing providers, the methodology is more complicated. The customer first identifies the counties he or she has to pass through. Then he/she contacts the individual county transit services including their origin, intermediate points and destination. The customer may need to explain the purpose of the trip to all service providers to obtain information about the routes, timings, restrictions, and transfers. Once the customer gathers all the information, the customer identifies the transit services he or she needs to use to reach the destination. The timings get calculated and if the customer comes up with a feasible trip plan, then the individual agencies are called and reservations are made if necessary. This process could be vastly improved (simplified) by implementing a single source of transportation information and a trip planning tool.

In addition to the usual lack of a single source of transportation information, rural transit operates differently than urban or suburban transit due to the characteristics of a rural environment. Rural transit systems' vehicles are often smaller. Demand responsive service or deviated routes are common. Often, rural service includes routes to urban centers, and frequency can be in terms of days as opposed to minutes in the urban environment. In addition, many urban transit providers have implemented various technologies to improve the efficiency of their operations, and increase the use of technology by their customers. Some of these technologies include:

- Automatic Vehicle Location (AVL) and Mobil Data Communications (MDC)
- Next Bus Signs
- Trip Planning Tools

However, there are limited deployments of such systems in rural environments. Technology can be used to improve the effectiveness and efficiency of individual transportation providers, and to enhance transportation coordination.

The benefits of coordinated transportation have been document in various sources, including the recent publication of *TCRP Report 91: Economic Benefits of Coordinating Human Service Transportation and Transit Services* [4]. In fact, the Ohio Department of Transportation noted that coordinating transportation services is "the best way to stretch scarce resources and improve mobility for everyone." Coordination efforts can be enhanced through the use of technology. As shown in Table 2, there are a host of technologies that can be utilized to enhance not only coordination, but the operations of individual public transportation providers.

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Table 2: Transportation Provider's Needs vs. Technologies

NEEDS	APPLICATIONS														
	Accounting Software	Automatic Passenger Counters	Automatic Vehicle Location Systems (AVL)	Communications	Customized Spreadsheets and Databases	Demand-Responsive Transit Software - Automated	Demand-Responsive Transit Software – Computer Assisted	Electronic Payment Systems	Geographic Information Systems (GIS)	Internet website	Maintenance Software	Silent Alarm System	Mobil Data Communications / Terminal	Palmtop Electronic Manifest Device	Personnel Management Software
More Accurate, Easier Reporting and Record Keeping	X				X									X	X
More Efficient Service Coordination		X	X	X	X	X	X		X				X		
Safer, More Accurate Cash Handling					X								X	X	
Improved Operations, Staff Performance, and Productivity			X		X	X	X		X				X	X	
More Effective Maintenance Tracking					X						X		X		
Clearer Communication			X	X									X	X	
More Effective Dispatching			X	X	X	X	X				X			X	
Faster, More Efficient Trip Request Processing						X	X		X	X					
Improved Scheduling Productivity			X		X	X	X		X				X		
Improved Service Quality			X		X	X	X		X				X		
Greater Safety			X		X	X	X						X		
More Accessible, More Useful Customer Information			X		X	X	X		X	X					

Source: Technology In Rural Transit: Linking People With Their Community [5]

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In short, the following factors point to the need for changing the way transportation information and services are provided in rural California:

- Currently there is no trip planning capability; the burden of obtaining information, planning the trip, and making necessary reservations or arrangements between the service providers rests on the shoulders of the customer.

- The dispatcher for an individual service provider has limited information about other service providers in the region.

- Each transit website in the region describes their service in a different way. This complicates a customer's attempt to understand service in multiple regions. Furthermore, some of the transportation services are eligibility oriented, and other services such as door to door paratransit systems need 24 hour advance reservations.

- Coordination between transit services is limited to informal communication via telephone between service providers.

- If information were more easily available, people may be encouraged to try public transportation services.

- Coordination is a proven tool to increase the effectiveness and efficiency of transportation (transit) providers.

This section (Section 2) highlighted how the current system operates, and the need for changes to the current system. The next section describes the proposed changes to the system.

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Figure 4. 4 - Western Transportation Institute Concept of Operations and Action Plan

This figure shows Section 2, which describes the current situation regarding information availability for trip planning in a rural region and identifies the need for change that will be addressed by the proposed system.

4.3.5 System Overview

The Regional Concept of Operations should provide a high-level description of the interrelationships of key system components, their scope and interfaces. The section describes all aspects of the integrated system at once. This information is often most effectively conveyed via a diagram.

In Figure 4.5 the Concept of Operations for the VII Michigan Test Bed Program provides the system overview in Section B of that document.

Regional Example

VII Michigan Test Bed Program

Concept of Operations

B. What – What are the Known Elements and the High-level Capabilities of the Michigan VII Test Bed Program?

Test beds are anticipated to consist of four different subsystems– on board equipment, roadside equipment, network management and data processing. Test facilities are anticipated at the OEM Facilities, supplier and other test bed participant facilities, and MDOT and other local road agencies, on roads and parking lots and in laboratories, research facilities, and control centers. **Figure 2** outlines conceptual linkages between the various test bed elements, and does not prescribe a design for attributes that will be particular to each separate Test Bed. As such, it is meant to be a guide to use for the planning, design, implementation, operation and maintenance of test bed elements and interfaces. It should be noted that the test bed architecture is using the Internet as a means to transmit data from the roadside device to the test bed participants. Each participant will be responsible for securing their data packets.

Vehicle Equipment Subsystem

The Vehicle Equipment Element within the Test Bed will consist of privately-owned vehicle fleets that will collect data for use in testing the feasibility to collect and communicate data to / from the infrastructure. Vehicle fleet equipment will be the full responsibility of each individual test bed participant or participant team. In addition, it is envisioned that, for the duration of the VII Michigan Test Bed Program, each Test Bed will utilize a dedicated fleets of vehicles, owned by those organizations participating in the Test Bed activities. This arrangement will provide less problematic access to vehicle data due to privacy agreements made with employees rather than the general public.

Data from vehicles will be:

- Collected for use by both the private-sector and the public-sector stakeholders

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- Archived for the purpose of allowing stakeholders to research and develop the means to fuse, package and disseminate information to other users (e.g., Independent Service Providers, telematics, etc.) and infrastructure (e.g., CCTV cameras, Dynamic Message Signs, etc.) in support of their agency or organization's goals and objectives.

The VII test bed fleet will transmit data packets using Internet Protocol (IP), to each respective test bed participant or participant team's VII server. Data required by MDOT, including the data format, will be set forth in a requirements document that will be shared with the private-sector stakeholders for their use in designing a Test Bed.

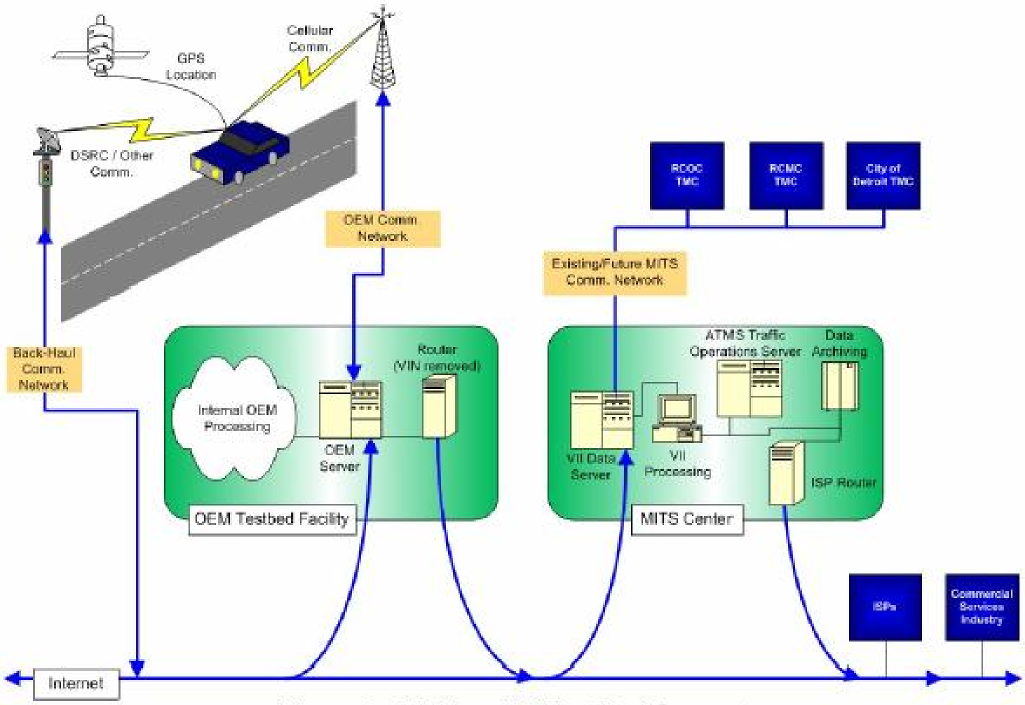

Figure 2 – Michigan VII Test Bed Concept

Roadside Equipment Subsystem

The Roadside Equipment Element within the Test Bed may include a variety of system components that will depend on the design developed for each particular Test Bed. For Test Beds that will utilize a non-cellular communications medium, the roadside equipment will be located within the public-sector right-of-way and is anticipated to receive data from Test Bed vehicles. Data will either be processed or forwarded along the Internet to OEM Test Bed facilities, depending on the nature of the test activities. Subsequently data will be transmitted to MDOT once the data is anonymized (the Vehicle Identification Number (VIN) or other identifiers, are removed from the data packet).

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Network Management Subsystem

The fundamental building blocks of the VII concept are coordinated deployments of communication technologies in all vehicles by the automotive industry and along all major U.S. roadways by the transportation public-sector. Short-haul vehicle-to-roadside communications are anticipated to occur via high-speed licensed (e.g., Dedicated Short Range Communications) or unlicensed (e.g., 802.11, WiMAX, etc.) short range wireless communications. Data will then be back-hauled via wired or wireless media that may be leased or agency owned, to an Internet field portal, for transport to the OEM Test Bed servers. Initial test bed deployments will focus on the use of 802.11-based technologies to facilitate vehicle-to-roadside communications.

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Private Sector Test Bed Facilities Element

At a minimum, Private Sector Test Bed facilities will collect, store, anonymize and disseminate data from either the Vehicle Fleet or Roadside Equipment Elements to the MDOT/Public-Sector Element and the Vehicle Fleet. The private sector test bed participants will then forward the appropriate anonymized data to the public sector participants via the internet for public sector use and analysis. The raw data may be used by the private sector partners for their own purposes. Existing private sector Test Bed facilities within the VII Michigan Test Bed Program (as of August 2005) include:

- Ford Motor Company (Dearborn)
- DaimlerChrysler (Auburn Hills)
- Nissan Motors North America (Farmington Hills)
- Collision Avoidance Metrics Partnership (CAMP) (Farmington Hills)
- Motorola (Farmington Hills)
- General Motors (Detroit)
- University of Michigan Transportation Research Institute (UMTRI) (Ann Arbor)

MDOT/Public-Sector Element

Each OEM Test Bed Facility will interface via the Internet with a server housed within the Michigan Intelligent Transportation Systems Center (MITSC). The MDOT server will be dedicated to collecting, processing, and distributing anonymized VII data. MDOT will be responsible for disseminating final VII data to other public-sector partners, including:

- Road Commission for Oakland County
- Road Commission of Macomb County
- City of Detroit

In later stages of the Program, data may further be shared with other industry stakeholders for use in traveler information applications, including Information Service Providers (ISPs), commercial services industry, and media outlets. As these later stages approach, issues associated with sharing this data, such as confidentiality and non-disclosure agreements for certain information, will be addressed at the local level based on the decisions made and directions being set forth at the national level.

C. When – What is the Time-Sequence of VII Michigan Test Bed Program Activities that will be Performed?

The VII Michigan Test Bed Program is a multi-phased program which will be implemented over time from 2005 through 2008 to coincide with development efforts in the private sector and Field Operational Test plans in the public sector. Major segments of the region-wide Test Bed (Phase 3) are planned for deployment by the 4th quarter of 2007. This region-wide Test Bed (Phase 3) will be an expansion of the initial, localized Test Beds (Phase 1), that will eventually be expanded in geographic coverage (Phase 2). These expanded Test Beds, along with additional future Test Beds, will ultimately be linked in Phase 3 to evaluate the interoperability of the various locations and technologies. **Figure 3** depicts the high-level phased approach.

Figure 3 depicts the test bed locations in a clouds reference. Future meetings and developments in the VII community – both locally and nationally – will determine the exact locations of various roadside devices, and their coverage ranges. For example, some of the test bed areas described below are intended to provide continuous coverage along an entire corridor or series of corridors. Others are focused at specific intersections.

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To accomplish this deployment, the following two things must occur by summer 2008:

1. Deployment of a Test Bed that will utilize a combination of products and technologies to demonstrate the technical feasibility and interoperability of collecting and forwarding VII data thru the use of open-standards and an open-architecture. This "Interoperable Test Bed" could leverage the above-captioned individual Test Beds as well as other Test Beds that have yet to evolve.
2. Continued support within the public and private sectors of the VII program that ensures that the VII program is not limited to either a geographic area or a subset of automobile manufacturers.
3. Successful testing and pre-deployment activities that demonstrate a marked improvement (or demonstrate significant potential improvements) in safety and congestion, while demonstrating the ability of VII to meet the overall goals of the National and Michigan VII programs, as well as those of the suppliers and original equipment manufacturers at an acceptable cost to benefit ratio.
4. The successful deployment of a series of individual Test Beds that prove the technical feasibility to collect and forward data in a fashion that can support VII. The VII Michigan Test Bed Program is well along the way of successfully deploying multiple Test Beds, including the following:

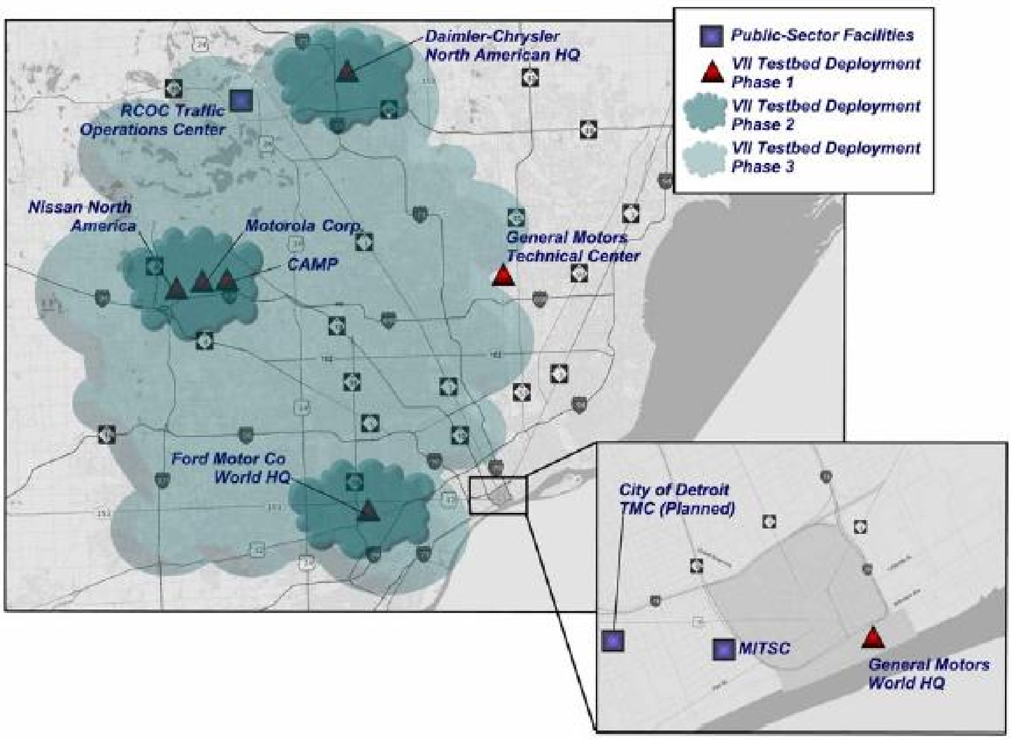

Figure 3 – Phased Test Bed Deployment

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VII Michigan Test Bed Program *Concept of Operations*

- Ford Test Bed - Ford Motor Company, MDOT, Wayne County and the City of Dearborn are partnering to develop a test bed near Ford's facilities in Dearborn. The initial deployment will include the installation of a Motorola Canopy short-haul wireless network around three intersections along City roadways aimed at achieving full wireless VII coverage of a triangular configuration formed by three roadways.

- DaimlerChrysler Test Bed – DaimlerChrysler, MDOT and RCOC are partnering to develop a test bed along the roadways surrounding DaimlerChrysler's Auburn Hills headquarters and technical center. The test bed will include deployment of DSRC-surrogate (802.11) radios at signalized intersection locations along public roadways.

- General Motors Test Bed – General Motors is evaluating the use of data collected from its OnStar™ cellular network for use in VII applications. In partnership with MDOT, GM will begin sharing anonymized OnStar™ data via the Internet with MDOT for MDOT use. The GM test bed in Warren includes detection to permit GM to validate the accuracy of probe vehicle data in comparison with data collected from traditional ITS methods.

Figure 4. 5 - VII Michigan Test Bed Program Concept of Operations

This figure shows Section B, which describes known elements and high-level capabilities of the Michigan VII Test Bed system. A diagram of component interrelationships is included

4.3.6 Operational Environment

This section describes the "world" in which the proposed system will operate. This information will support Operations and Maintenance budgeting and funding decisions.

Section 7 of the Kansas DOT Concept of Operations for a statewide Transportation Operations and Management Center breaks down its operational and support environment into five categories: facilities, hardware, software, personnel, and communication needs. See Figure 4.6 below.

Regional Example

Kansas Statewide Transportation Operations & Management Center Study

Transportation Operations and Management Center

7 The Operational and Support Environments

This section describes the environment or "world" in which the TOMC will operate. This section includes information about the TOMC's environment in terms of the following categories:

- Facilities
- Hardware
- Software
- Personnel
- Communication Needs

The information in this section is based on stakeholder feedback, past experience of the Project Team, and Project Steering Committee input. This section summarizes the information contained in the Statewide TOMC Implementation Plan. For additional detail, please refer to that document.

7.1 Facilities

One of the reasons that the Virtual TOMC concept was selected was to minimize space impacts and eliminate the need for a dedicated facility or building to house the TOMC. It is envisioned that the TOMC application will be installed on work station computers that will utilize existing office spaces and desks. These work stations will be located in each District, likely at the District headquarters building. The designated operator can utilize their existing office to house the work station or a dedicated desk/office can be used. It will be up to each District to determine what configuration works best. At KDOT headquarters, the work station can be located in a designated office, most likely the responsibility of the Division of Operations. In addition, KDOT may desire to load the application on a portable workstation that could be used in a conference room for demonstration purposes or for events requiring a group of decision makers to gather. Partner agencies such as the Kansas Highway Patrol may wish to locate their workstation at the Salina dispatch center in the dispatch room for easy access. The Kansas Division of Emergency Management may wish to locate their workstation in their main conference room for gathering officials in the event of a statewide emergency.

The computer servers will require space in a KDOT equipment room and will probably be installed in existing server racks without need for additional space. If additional space is required, KDOT should plan on two racks to provide space for the TOMC software server, a communications server, and a video server along with the associated cabling. In addition, if CCTV communications are to be district based, room for a video server should be planned in each district office.

7.2 Hardware

7.2.1 Typical TOMC Hardware Requirements

The primary new hardware required for the TOMC will be central servers designed to support the TOMC software application. The number of servers required will be based on the software requirements for the TOMC, but a typical system might require as many as three servers to support all of the subsystems needed to provide statewide

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operations. Secondary servers to support communication, archiving, and sharing of information with partner agencies and organizations will also be needed. A typical system would require the following minimum server specifications:

One (1) Database Server

- **Dell Power Edge 2850**
- Intel® Xeon™ processor at 3.2GHz/1MB Cache, 800MHz FSB
- 2GB DDR2 400MHz (4X512MB), Single Ranked DIMMs
- 3 36GB Drives attached to embedded PERC4ei, RAID 5
- Dual On-Board NICs
- Windows 2003 Server, Standard Edition with Client Licenses
- 24X IDE CD-RW/DVD ROM Drive for PowerEdge Servers
- Embedded RAID (ROMB) - PERC4ei (Embedded Integrated)
- Riser with PCI-X Support and Embedded Raid (ROMB) Support
- Controller Card SCSI, 39160 Internal/External, U3, Low Voltage Differential
- 3Yr BRONZE Support, Next Business Day Onsite
- Keyboard / Mouse
- Dell E173FP Digital Flat Panel Panel Monitor,17 inch(17in Viewable)
- Rack Chassis w/Versarail, RoundHole-Universal
- Rapid Rails, Square Hole (Replacement for versa)

Two (2) Network / Communications / Video Servers

- **Dell Power Edge 2850**
- Intel® Xeon™ processor at 3.2GHz/1MB Cache, 800MHz FSB
- 2GB DDR2 400MHz (4X512MB), Single Ranked DIMMs
- 3 36GB Drives attached to embedded PERC4ei, RAID 5
- Dual On-Board NICs
- Windows 2003 Server, Standard Edition with 5 Client Licenses
- 24X IDE CD-RW/DVD ROM Drive for PowerEdge Servers
- Embedded RAID (ROMB) - PERC4ei (Embedded Integrated)
- Riser with PCI-X Support and Embedded Raid (ROMB) Support
- 3Yr BRONZE Support, Next Business Day Onsite
- Rack Chassis w/Versarail, RoundHole-Universal
- Rapid Rails, Square Hole (Replacement for versa)

It is KDOT's desire to have the TOMC servers and software reside in a central location, likely KDOT Computer Services in Topeka. For the TOMC software application, space for one server rack will be required in the central location. Communications equipment required will be based on ITS infrastructure in the field as will a video server with specifications based on the simultaneous video usage needed at the District offices. Space for these equipment racks, minimum 1, and the associated cabling, will be needed in headquarters and in the District office if field communications are routed through the District offices.

In order to run a typical COTS application, a PC with the following minimum recommended specifications is required:

Operator Interface (Workstations)

- **Dell Precision Workstation 370 Minitower**

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- Intel® Pentium® 4 Processor 3.00GHz, 1MB/800
- Microsoft® Windows® XP Professional, SP2 with Media
- 512MB, 533MHz, DDR2 SDRAM Memory, ECC (2 DIMMS)
- C1 All SATA drives, Non-RAID, 1 or 2 drive total configuration
- 80GB SATA, 7200 RPM Hard Drive with 8MB DataBurst Cache™
- 48X/32X CD-RW/DVD Combo w/ CyberLink PowerDVD
- 64MB PCIe x16 nVidia Quadro NVS 280, Dual DVI/VGA Capable
- Sound Blaster Audigy™ 2 (D), w/Dolby Digital 5.1 & IEEE1394a
- Serial Port Adapter
- Keyboard
- Mouse
- Dell Two Piece Stereo System
- Dell 19 inch UltraSharp™ Flat Panel, adjustable stand, VGA/DVI

These workstations are on the high-performance end and one should be supplied to each District (6), KDOT HQ (1), and partner agencies (2) as the main interface with the TOMC application for a total of 9 initially. Most modern workstations will be satisfactory to run a COTS application.

7.3 Software

7.3.1 TOMC Software Requirements

The TOMC is intended to be a software application that runs on a common server and is accessible through KDOT's existing networks for KDOT users statewide and to KDOT agency and private partners. Users will be provided user names and passwords. Level of access will depend on permissions assigned within the software for each user. KDOT users will have the highest level of access while partner agencies and organizations will have more restricted access. The software must address the 15 TOMC functional requirements as well as certain basic requirements. These basic requirements include:

- Support center to center (C2C) and center to field (C2F) communication
- Scalable, upgradeable, and modular design
- Compliant with NTCIP
- Able to communicate with devices from different vendors
- Able to handle different signal formats (NTSC, PAL etc)
- Share real time information over WAN / LAN
- Support multi-user multi-priority level access
- Backup operations at other centers
- Allow user access from remote terminals

7.3.2 TOMC Software Model

There are several ways to implement TOMC software: purchase a statewide license for "commercial off-the-shelf" or COTS software; acquire "freeware" and utilize a programmer to customize it for KDOT's use; utilize a programmer to develop new software; or, modify existing KDOT software such as KanRoad. The key to selection of software will be functionality relative to the 15 TOMC functions, costs and timeframe for implementation. It will also be necessary to determine how long-term support for the

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software will be provided. Will KDOT be able to support the software in-house or will vendor support be required?

7.4 Personnel

Staffing hours for the Kansas Statewide TOMC will be highly variable. Factors that influence staffing hours include:

- Complexity or simplicity of TOMC user interface related to the TOMC functionality.
- Types and quantities of integrated ITS field devices available to TOMC users.
- Intensity of active events, incidents and/or emergencies.
- Need for KDOT or other partner participation in a particular event.
- KDOT policies on frequency and timeliness for updates to messages on DMS and HAR and for providing messages and updates to external partners.
- Centralization (Statewide or District) or decentralization (Area, Sub-Area, Maintenance Worker) of TOMC monitoring, control, and input responsibilities.
- Frequency, scope, and duration of system and communication tests and diagnostics.
- Reliable or frequently maintained or repaired communication, ITS field devices, and networks.
- Availability of staff and budget to monitor TOMC functions.
- Availability of key staff after hours or on-call staff to monitor TOMC functions.
- Ability for TOMC users to access the TOMC interface from home or other convenient locations.

The amount of training and the number of people to be trained are influenced by the same factors. KanRoad, for example, is updated by over 300 people throughout KDOT. Not all the staffing hours required or recommended for TOMC should be considered new hours. In some cases, TOMC hours replace, and hopefully streamline, effort already expended by the Districts during events and incidents.

7.4.1 Estimated TOMC Daily Hours

It is estimated that the TOMC will require one to two hours per day during normal operations at the District level and about the same at the headquarters level in Computer Services for routine checks and system/server maintenance. Table 7-1 identifies many of the activities that could be done on a daily basis during normal operations. Although these activities will not require a full-time equivalent position either in KDOT Headquarters or the KDOT District, individuals will need to be assigned duties related to TOMC activity.

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Table 7-1: TOMC Daily Staff Activities

KDOT Computer Services	HQ and District Construction & Maintenance Operations	KDOT Partner Agencies & Organizations
▪ Verify server function and network connectivity ▪ Update TOMC administration controls (user names, password, level of access) ▪ Archive TOMC data ▪ Respond to District or Partner Agency TOMC malfunction notifications and/or support requests ▪ Maintain dedicated ITS communications backbone between KDOT network and field devices	▪ Update KDOT contact information ▪ High-level TOMC system availability check ▪ High-level TOMC field device availability check ▪ High-level communication function check ▪ Verify accuracy of messages on active DMS, HAR ▪ Verify camera views are appropriate ▪ Report problems noted to Computer Services or applicable KDOT staff ▪ Perform traffic management for work zones	▪ High-level system availability check ▪ Check for alerts or other TOMC messages from KDOT ▪ Report problems to KDOT using TOMC contact information

7.4.2 Estimated TOMC Weekly Hours

It is estimated that TOMC will require two to four hours per week during normal operations at KDOT Headquarters by Computer Services personnel for system testing and diagnostics and two hours per week by District staff and partners to conduct training exercises. Table 7-2 identifies the activities that should be done on a weekly basis.

Table 7-2: TOMC Weekly Staff Activities

KDOT Computer Services	HQ and District Construction & Maintenance Operations	KDOT Partner Agencies & Organizations
▪ Perform full TOMC system diagnostics ▪ Maintain ITS communications backbone	▪ Conduct system training and exercises with HQ and District staff ▪ Perform system testing in conjunction with Computer Services	▪ Conduct system training and exercises with organization staff in conjunction with KDOT

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7.4.3 Estimated Minimum TOMC "As-Needed" Hours

During events and incidents, hours will be more extensive. During events and incidents other demands on KDOT staff also peak. Depending on the duration, extent, and transitional nature of the event, KDOT effort relative to the TOMC will be highly variable. Another factor on TOMC effort will be the nature of KDOT policies regarding TOMC operations. It is estimated that TOMC activity could range from 25% to 30% of a full time person per District during active events. Many events last more than one shift. Long, continuous events may require TOMC operation for more that one day during the event. Staffing would be less per person if TOMC operations were distributed to Areas and Sub-Areas, but probably more in total. For the purposes of this estimate, an average major incident duration will be three hours, an average storm event duration will be 24 hours, a flooding event will be six hours, and a statewide emergency will last 48 hours. Table 7-3 describes as-needed TOMC activities.

Table 7-3: TOMC As-Needed Staff Activities

KDOT Computer Services	HQ and District Construction & Maintenance Operations	KDOT Partner Agencies & Organizations
▪ Perform on-call services to maintain the system during emergencies ▪ Update TOMC integration with field devices, external partners, etc. as needed when new devices are added. ▪ Repair servers, update software, add users, replace equipment as needed.	▪ View and control CCTV ▪ Activate DMS, provide DMS messages ▪ Activate HAR, provide HAR messages ▪ Update HAR and DMS messages ▪ Deactivate HAR and DMS messages ▪ View traffic detector information ▪ Send alerts to media, adjacent states, and KDOT partners ▪ View flood monitors ▪ Notify adjacent District when control of DMS or CCTV is needed per KDOT policy ▪ Utilize TOMC input and output pages as needed to communicate with internal KDOT and external agencies and organizations. ▪ Monitor KDOT field assets and vehicle locations ▪ Maintain and/or repair ITS field devices	▪ Review KDOT alerts ▪ Respond to KDOT alerts as appropriate ▪ Provide information to KDOT when applicable ▪ View and control CCTV ▪ View traffic detector information ▪ Perform statewide coordination for major emergencies ▪ Notify the media of events and disseminate information to the public

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7.4.4 Estimated Full-Time Equivalent (FTE) Requirements

Based on the estimation of duties and hours per day, per week and per special event required for personnel in each KDOT District, KDOT Computer Services, KDOT Headquarters Operations Division, and partner agencies such as the KHP and KDEM, a total FTE requirement has been calculated for each work group. As shown in Table 7-4, the total FTEs required for each work group per year all fall short of the need for at least one FTE. Partial FTEs are all that is estimated to be required to operate the TOMC in any of the work groups. The importance of this number is that there is likely not enough TOMC duties to keep any one person occupied full-time. TOMC duties will fall upon existing personnel and in addition to other assigned duties.

As has been stated by members of the Project Steering Committee and Project Stakeholders, there are very few available FTEs to dedicate to TOMC functions on a full-time basis and that those duties will need to be assigned to existing personnel who already have defined duties. Even though the FTE requirements shown in Table 7-4 are fractional, they are still a significant amount of one person's total duties, especially in Computer Services and each District. Therefore, when the TOMC duties are assigned, they should be assigned to personnel that have the work load capacity to handle the duties effectively.

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Table 7-4: Estimated TOMC FTE Requirements

Event	Events/Yr[1]	Duration Per Event (Hours) Computer Services	Total Hours/Yr	HQ Operations	Total Hours/Yr	District Operations	Total Hours/Yr	TOMC Partners	Total Hours/Yr
Daily Activities	260	2	520	1	260	2	520	1	260
Weekly Activities	52	4	208	2	104	2	104	2	104
Snowstorm	6	2	12	2	12	24	144	2	12
Major Incident/Road Closure	5	0	0	3	15	3	15	1	5
Flooding	4	0	0	0	0	6	24	2	8
Statewide Emergency	1	48	48	48	48	48	48	48	48
TOTAL HOURS/YR			**788**		**439**		**855**		**437**
Full-Time Equivalents (at 2080 hours/yr)			**0.4 FTE**		**0.2 FTE**		**0.4 FTE[2]**		**0.2 FTE**

1 - The number of events per year are considered to be statewide for estimating purposes. Even though each District will not experience the number of snowstorms, major incidents, and flooding events shown, these events tend to affect more than one District per occurrence. No adjustment in the total hours per each District has been made.

2 - The 0.4 FTE figure is per District.

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7.4.5 Typical TOMC Staff Positions

The following position descriptions are general in nature but describe what skill sets are necessary for typical positions to be staffed in a TOMC. The FTE requirements noted above do not necessarily refer to just one person, but rather may be a collective of people, each with a particular skill set described below. For the Computer Services FTE, that may include a System Administrator, Communications Technician, and Software/Computer Support. The Headquarters FTE will include skills closely related to that of an Operations Supervisor and System Operator. The District FTE will closely match the System Operator and Operations Center Technician. Partner Agency FTEs will be similar to Operations Supervisor and System Operator.

Operations Supervisor / Shift Supervisor: This position is frequently filled by a person who came up through the ranks and achieved competence through a blend of job-related training and personal experience. The supervisor must have a well-developed judgmental skill that allows him/her to distinguish between situations that can be handled within the resources of the operations center and those that require the participation of one or more partner agencies. This person is responsible for the management of previously developed operating plans, including the magnitude of the response to implement based on the type of incident. Another skill highly prized in a supervisor is the ability to teach others how to be excellent system operators. The operations supervisor manages the daily operations of the TOMC operations staff and performs a number of reporting and administrative duties. The shift supervisor is in charge of the staff operations for their shift.

Systems Administrator: This position is filled by a person will all of the skills described for the software/computer support position plus this position requires a thorough knowledge of the local area network (LAN) or other network structure that is operating within the TOMC. The system administrator is responsible for the maintenance and upgrading of the TOMC network. The system administrator will maintain the systems security by providing the needed system access to various staff or contractors via passwords. Often the system administrator will manage the software/computer support personnel.

System Operator: This is the hands-on position. The system operator must be computer literate and capable of performing many computer-related skills, such as keying in text data and using a mouse. Most ITS systems are actually composites of several different subsystems, so the system operator must be familiar with the operating commands of several different systems. A typical combination could include Highway Advisory Radio (HAR), dynamic message signs (DMS), and ramp metering, as well as a CCTV surveillance system. Each of these subsystems may have a different operator interface, and the system operators must be fully trained on all of the systems.

Software/Computer Support: While it is possible for an operating agency to maintain the real-time system software, this is generally not the case. A contractor generally maintains the real-time system software. There is a need, however, for software and hardware support in the operating agency. This level of computer skill would require proficiency in the data base management programming languages, including Oracle® or

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Sybase®. In addition, the programmer must be proficient in GIS and CADD software packages (e.g., ARC/INFO®, ArcView®, AutoCAD®, MapInfo®, and Microstation®) and firmware for traffic signal controllers (e.g., National Electrical Manufacturers Association, 170,270, and 2070) on Mac®, Sun®, and HP® platforms, as well as the software specifically installed in the TOMC to manage traffic operations. The primary task of the software/computer support personnel is to maintain the software necessary to track maintenance operations and support the operations function.

Communications Technician: This position requires an electronics technician who is trained in the operations of a variety of wireline, wireless technologies, and radio communications (AM and FM) systems supporting video, data, and voice transmissions. An evaluation of the capital cost of the equipment in any ITS system will show that the category with the highest investment is communications. It only makes sense to protect this investment by providing a high level of maintenance. This category is not only the largest but also the one that changes most frequently. As communications hardware evolves, it becomes almost a steady state situation where one subsystem or another is always being upgraded and/or replaced.

Operations Center Technician: This is an electronics technician who may be junior to the communications specialists but nevertheless has been trained in the maintenance of digital electronic equipment, particularly microprocessors. This person can identify hardware failure and make repair/replace decisions. The position requires considerable troubleshooting skills as well as the ability to perform all types of testing.

7.5 Communication Needs

The development of communication requirements for future ITS infrastructure in Kansas will be the speculative at best due to the lack of knowledge of future deployments, future communications technologies, cost variability (either up or down), use of state-owned infrastructure versus leased communication lines, and potential cost sharing between multiple agencies. The following presents a representation of the communications infrastructure existing in Kansas and future communication options.

7.5.1 TOMC Communication Requirements

KDOT is currently using T-1 lines to provide network communication between District Offices. As ITS field devices, particularly traffic cameras, are deployed, the demand for Center-to-Center (C2C) communication will increase beyond the current capacity of the T-1 lines. Network communication to IP addressable devices in the field can be accomplished with most ITS equipment that are only exchanging data such as DMS and detection devices. The use of cameras and transporting of video is going to be the key factor in determining communication requirements.

KDOT owns fiber optic cables and conduit across the state as shown in Figure 7-1. These cables can currently, or with additional last mile connections, be used to provide communication between KDOT Headquarters, Districts 1, District 2, and the Kansas City and Wichita urban areas. The fiber can also be used to connect with partner agencies such as KHP and KDEM in the Topeka and Salina areas as well as any ITS elements

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that are located along roadways with adjacent fiber optic cabling. Fiber is not currently available to connect to District offices in Norton, Garden City, Hutchinson or Chanute.

7.5.2 Communication Options

Center-to-Center Communication

Table 7-5 shows several options are available for increasing bandwidth for C2C communications. These options include leasing additional T-1 lines, installing additional fiber, or digital microwave wireless communications. Leasing costs for T-1 lines can be very expensive over the long run. Installation of fiber provides the largest potential bandwidth but also the highest initial costs. Microwave communications may be a cost effective alternative. However, depending on the frequency band utilized, weather could cause disruptions to microwave transmissions. A thorough frequency analysis will be required to ensure frequency availability and line of sight availability for placement of towers.

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TOMC Concept of Operations
September 2005

Figure 7-1: Constructed Fiber Optic Routes in Kansas (KDOT Owned)

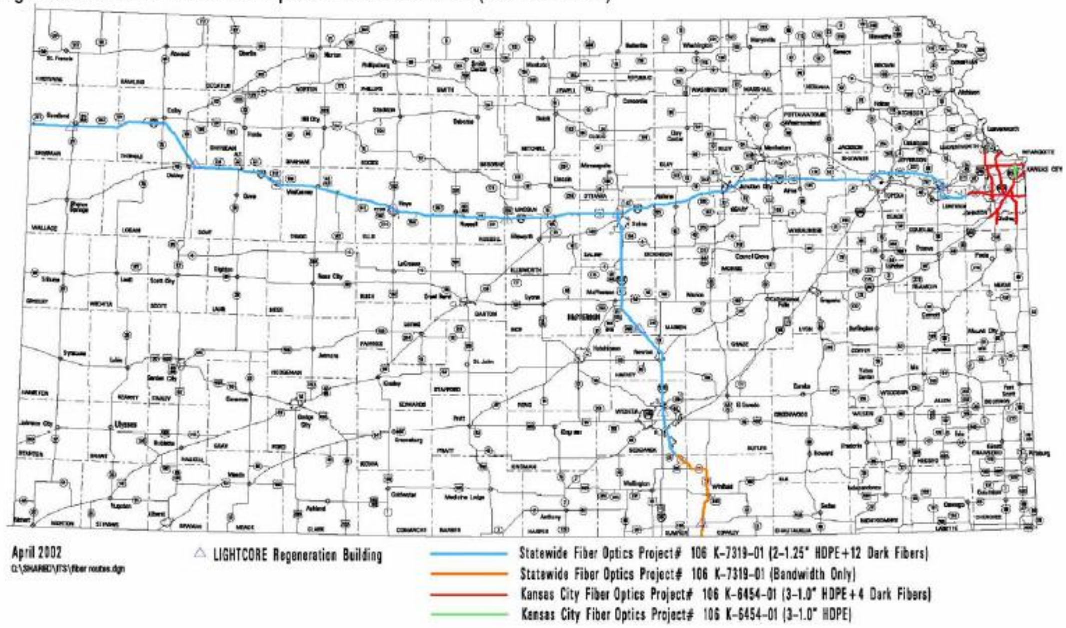

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Table 7-5: C2C Communication Options

Communication Option	Initial Costs	On-Going Costs	Data Capacity	Comments
T-1 Lines	Low Low initial cost if leased.	Moderate Recurring lease costs.	1.54 mbps	Useful for most data applications, but limited usefulness for video.
T-3 Lines	Low Low initial cost if leased.	High Recurring lease costs.	45 mbps	Probably adequate capacity for sharing video between centers.
Fiber	High Costs include conduit, cable and equipment to light the fiber.	Moderate	1,000 mbps	Example is Gig-E Ethernet. Fiber capacity is "unlimited" depending on number of fibers and use of multiplexing.
Digital Microwave	Medium A major factor is cost of towers.	Low	155 mbps	Can be multiples of 155 mbps depending on technology. Most microwave bandwidths require FCC license.

Center-to-Field Communication

In the Kansas City metro area, Center-to-Field (C2F) communication is being accomplished by fiber, especially where traffic cameras are present. In rural areas C2F communication is typically by telephone line (RWIS field devices) or cellular telephones. Cellular could continue to play a significant role for ITS field devices except for traffic cameras. Cellular, though, does have an inherent weakness in that during emergencies cellular tower capacity may be exceeded limiting availability of communication with ITS field devices. Some regions and even some states are developing agreements with local cellular companies for "always-on" cellular connections with ITS field devices. Where these agreements have been implemented reliability of cellular for C2F communication has been increased.

If available from the local telephone companies, Integrated Services Digital Network (ISDN) telephone circuits could be used utilizing MPEG4 video compression equipment to provide low cost video transmission from remote cameras to the TOMC. This would not provide full motion video, but somewhere in the range of 15-20 frames per second. This type of installation would be recommended where easy access to fiber or wireless access points is not available. Costs for leasing an ISDN circuit typically ranges from $50-75 per month per end, not including any long distance charges that could apply. The MPEG4 video compression equipment and ISDN interface equipment will cost approximately $1500-2500, depending on the specific vendor selected.

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Figure 4. 6 - Kansas DOT TOMC Concept of Operations

Section 7 of the Kansas DOT Concept of Operations for a statewide Transportation Operations and Management Center breaks down its operational and support environment into five categories: facilities, hardware, software, personnel, and communication needs.

4.3.7 Operational Scenarios

In this section, the proposed system is described under various operating conditions relative to the core users and the stakeholders. This is an important aspect of a Concept of Operations as it demonstrates how the envisioned system' operates under conditions that stakeholders and users expect.

The Concept of Operations (Figure 4.7) for the deployment of an Automated Vehicle Location System in the Lincoln, Nebraska metropolitan area provides five scenarios that describe "how the proposed system should operate and interact with its users and its external interfaces under a given set of circumstances". (City of Lincoln StarTran Automated Vehicle Location System Concept Of Operations, prepared by: Mixon/Hill, Inc., November 2005)

Regional Example

City of Lincoln

StarTran Automated Vehicle Location System

Concept Of Operations

5 OPERATIONAL SCENARIOS

The following scenarios describe situations in which the StarTran AVL system could improve operations and safety. Each scenario is a step-by-step description of how the proposed system should operate and interact with its users and its external interfaces under a given set of circumstances. The scenarios will tie together the system, the users, and other entities by describing how they interact.

5.1 Scenario 1: Bus Operator Automated Systems

Marcel, a StarTran bus operator, usually begins his work shift with administrative activities. After receiving supervisory direction, he boards the bus and prepares the AVL system. He begins by logging into the system.

The system then prompts Marcel for the route to be followed. He enters the planned route number, and the AVL system retrieves the appropriate route and schedule information from the AVL system server. The bus' AVL system then asks Marcel to verify the appropriate route and schedule information were properly retrieved.

Once he provides verification, the bus' head sign is automatically updated to reflect the appropriate route information. The fare payment schedule is automatically adjusted to reflect the verified route, modified as necessary by the system clock to reflect any applicable time-differential rates.

The system then loads the appropriate bus stop announcements for the chosen route. These prerecorded announcements are consistent regardless whether Marcel or another bus operator is driving the route, and have been verified as ADA compliant. These announcements are then broadcast at the appropriate bus stop throughout the route.

5.2 Scenario 2: Security/Emergency Response

While performing her duties, a bus operator, Susan, notices an individual enter the bus. This individual was profiled on the previous evening's news as a person wanted for questioning related to a recent violent crime. Susan knows she must convey this information to the proper authorities, and do so in a manner that does not expose the other customers or her to potential violence.

Susan continues with her route as if nothing has happened. After leaving this bus stop, she uses the MDT to notify StarTran dispatch of the situation. James, the StarTran dispatcher, confirms receipt of her message, and advises her that the Lincoln Police Department has been notified.

James, who is still on the line with the Lincoln Police Department, accesses the bus' AVL system data. He relays to the Lincoln Police Department the bus' current location, its direction of travel, and the speed at which it is traveling. He then engages and accesses the real-time camera located within the bus. Using the information provided by the bus operator, James identifies the suspect and relays his seat location to the Lincoln Police Department as well.

The Lincoln Police Department notifies the nearest on-duty police officer, who follows the bus to the next stop. James advises Susan to stay parked at the next

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bus stop. At the next bus stop, the responding police officer enters the bus and apprehends the individual without incident.

While this process is documented for a security incident, the same interactions could occur for a health emergency.

5.3 Scenario 3: Trip Planning and Real Time Status Information

Mary Lewis is a retired schoolteacher. She regularly volunteers at the Lincoln City Libraries, and usually drives her car. However, her car is in need of body repair work, and will be in the shop for approximately a week. Mary's coworker suggests she use StarTran service while her vehicle is being repaired.

Mary accesses the StarTran website from the library's computer. She selects the trip planning function from the website, and enters her starting location (at home) and her ending location (the library), along with the time she needs to be at the library. The StarTran trip planning function provides the bus stop nearest her starting location and the time she must be there to catch the bus. It tells her she must make one transfer, and provides the transfer location and estimated wait time at the transfer station. The trip planner also provides the bus stop nearest her ending location and an estimated arrival time. Mary prints out the trip plan and takes it home with her.

The day arrives when Mary plans to take the bus to volunteer at the library. Unfortunately, inclement weather has entered the region and Mary does not wish to wait for the bus in the snow. Using the information she has saved on the printed page, Mary calls the StarTran route status line. After entering her bus stop and initial route information, the system advises Mary the bus is running 3-5 minutes behind schedule due to inclement weather. Mary uses the extra time to make sure she has her overshoes for the trip to the bus stop.

5.4 Scenario 4: Dispatcher Management of Routes and Schedules

StarTran has recently hired a new bus driver, Gregory. After passing the necessary examinations and completing his introductory training, Gregory has been assigned the #7 Belmont route.

Although he studied the route, Gregory has the normal apprehension associated with starting a new job and being concerned with performance. His dispatcher, Julie, advises him that she will use the AVL system to help ensure he is performing well.

Gregory starts his route at midday, and approximately 20 minutes in, experiences confusion over the planned route. He accesses the bus' AVL system, and using the inlaid route map loaded based on his login, he realizes he made a wrong turn. He quickly corrects his routing and continues with the remainder of the planned route.

Meanwhile, the AVL system has informed Julie that Gregory is off-route. By the time she accesses the system, he has returned to the proper route but is now behind schedule. The AVL system advises Julie he is behind schedule, and appears to be making up a little of the time. Julie contacts Gregory via the MDT and inquires about what happened. Gregory advises her he made a wrong turn,

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but corrected it and made sure he did not miss a stop. He is now trying to make up time at each stop so as not to impact the remainder of the afternoon's schedule. Julie reminds him the schedule has some cushion built in at the 2:40 p.m. Autumn Wood stop, and if he's diligent between now and then, he'll be back on schedule at that point.

5.5 *Scenario 5: Automated Fleet Management*

Manny, a StarTran Garage Supervisor, is responsible for scheduling maintenance for a percentage of the StarTran fleet. As part of his goals, he plans for as much preventative maintenance as possible, limiting the amount and expense of unanticipated equipment failures. He also knows that unanticipated equipment failures impact operations by requiring equipment rotation and perhaps contracting of additional equipment from Transport Plus.

Manny recognizes that a key to meeting his goal is regularly scheduled preventive maintenance. Realizing that scheduling every oil change to be performed in one day is not a practical method of accomplishing this goal. Using the daily mileage/hours reports automatically provided by the AVL system, Manny is able to plan needed preventive maintenance over the upcoming workweek.

Manny also utilizes the AVL system's real time equipment status alerts to receive notification of equipment functions that are reaching critical thresholds. During his shift, the AVL system sends Manny a pager notification regarding the #19 Salt Valley line bus. The bus' transmission temperature is reaching cautionary levels, indicative of possible impending failure. Manny contacts Louise, the responsible dispatcher, who has also received the same notification from the AVL system.

Manny and Louise determine the risk is low, as the bus is on the day's final run. However, Manny makes arrangements to pull this bus out of service at the day's end, and Louise makes plans to utilize alternate equipment while fleet maintenance personnel evaluate the bus and make any necessary repairs. The AVL system's notification has help avoid a potential transmission failure.

Regardless of the level of planning, unforeseen equipment failures will still occur. Such was the case when Manny received an AVL system pager notification about the #2 Bethany line bus' brake system failure. He quickly determines the failure will not permit a field repair. Almost simultaneously, Manny receives a call from Louise who has received the same notification. Louise advises Manny she has already made arrangements for a replacement bus to pick up the existing passengers and complete the route. While talking, Manny has accessed the bus' AVL system and has determined the bus' exact location and orientation on the roadway. He makes arrangements to have the bus retrieved and returned to the garage for repair. Because of the close coordination and the availability of real time information, the recovery team arrives just as the replacement bus has loaded the passengers. This minimizes the time the bus is disabled in traffic, thus reducing the secondary traffic flow impacts.

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Figure 4. 7 - City of Lincoln Automated Vehicle Location System Concept of Operations

Section 5 of the Concept of Operations for the deployment of an Automated Vehicle Location System in the Lincoln, Nebraska metropolitan area provides five scenarios that describe the operation of the proposed system under various user-expected conditions.

4.4 CHAPTER SUMMARY

This chapter reviewed the definition of a Concept of Operations in the context of a regional integration project. It noted that, while the definition is the same for all systems, the Concept of Operations description for a regional system must encompass more complex interactions and inter-relationships. The Core Elements of a Concept of Operations are illustrated here with regional examples in order to demonstrate scalability.

4.5 SPECIFIC LITERATURE SUPPORTING THIS CHAPTER

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